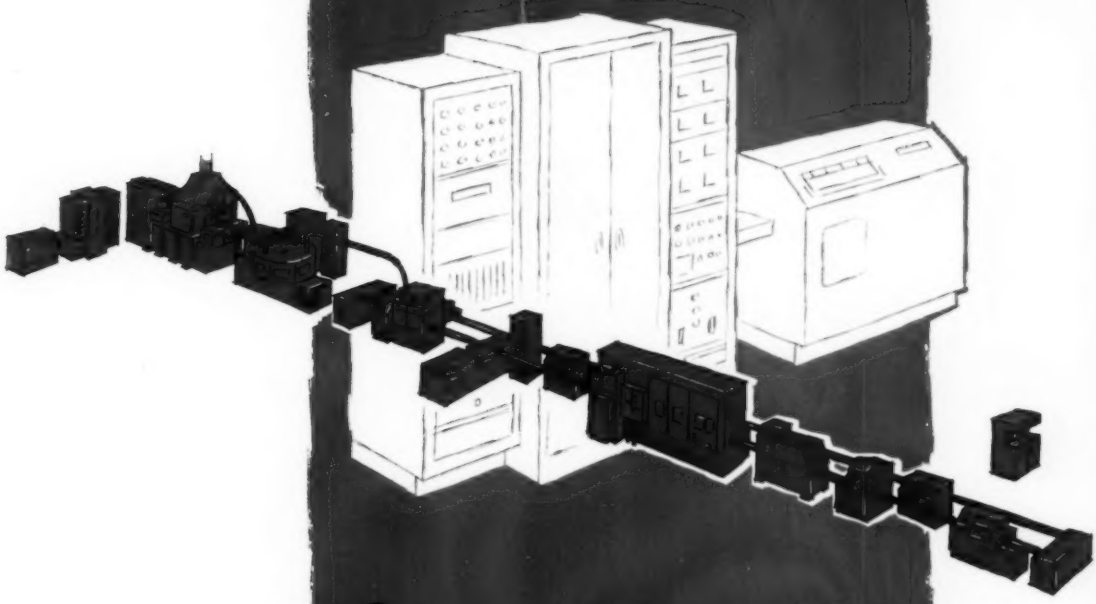
AUTOMATION

SEPTEMBER 1961



Computer-Controlled Manufacturing System

THE MAGAZINE OF AUTOMATIC MANUFACTURING OPERATIONS

- **Automatic Batch Weigher**
- **Transferring Methods**
- **Control Computer Application**
- **Electrohydraulic Servo Systems**

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A PENTON PUBLICATION

VAUGHN HAYES, Manager of Production Engineering, says:

"This Wean Slitting Line gives Chrysler Corporation's Twinsburg plant increased flexibility in production planning

by allowing us to purchase standard size mill coils. We slit these coils to meet specific production requirements, eliminating special-width coil purchases. The line's 2,000 ton-per-month output helps us eliminate production delays and coil supply problems." Mr. Hayes' comments are typical of reasons why companies are using the *coil processing concept* to lower material costs, reduce inventory requirements and decrease scrap loss. If you process 500 tons or more per month of flat rolled metals, write for our new brochure entitled, "Coil Processing."

This brochure explains the concept and economics involved in *coil processing*. It also illustrates the types of Wean equipment that can help you cut inventory, production, and material costs when you process standard *mill* coils instead of sheets.

The McKay Machine Company, Youngstown 1, Ohio.

The McKay Machine Company is licensed to manufacture, sell and service metal processing machinery formerly manufactured by Wean Equipment Corporation, Cleveland, Ohio.

LOOK TO
McKAY MCK MACHINE
FOR PROGRESS IN METAL PROCESSING

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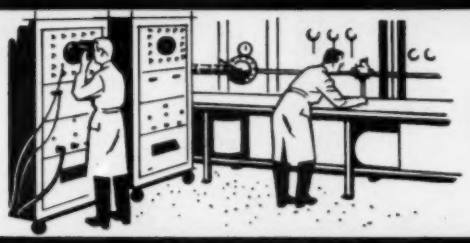

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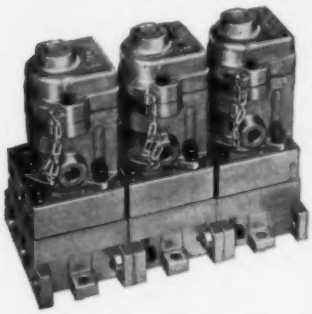
4 fine valves from the Ross valve line

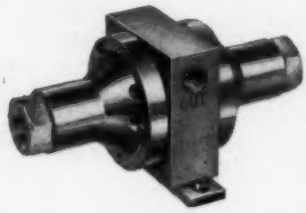


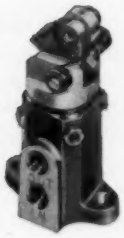
Fast valves manifolded

The PACER 4-way gives 1000 cpm and more, has all JIC features, is built for super long life. Manifold as many as you please. One air supply, one exhaust.

For greater press safety

The Non-Tie-Down valve is designed to protect the press operator's hands. Requires the operator to activate two separate valves continuously during a machine's cycle.





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The PCB valve—A ¼" valve with low minimum operating pressure—5 psi to 125 psi—that is fast operating and ruggedly built. Overriding cam activates valve from one direction only.

Air operation with momentary action on a 4-way, 5-port

Need to send a cylinder home hard but return it softly . . . or vice versa? This 4-way, 5-port lets you supply two different pressures to the cylinder. And the air index adaptor gives you momentary action. The main valve reverses and stays put with each air impulse delivered to the air operated head.

For more information write us, or contact your nearby Ross representative. See our digest catalog in Sweet's

THE WORLD'S MOST COMPLETE LINE OF AIR CONTROL VALVES. AVAILABLE ALL OVER THE FREE WORLD.

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First from LeBlond Continuous-Path Tape Controlled Lathes

Talk to LeBlond about Tape-Turn lathes. You'll be talking about machines we've got on the run off floor rather than on the drawing board. We're delivering at least six months ahead of competition. Our experience can help you get an important edge on *your* competition.

Tape-Turn is being built with 20 to 75 hp in sizes from 2013 to 4025.

100% tape commanded by G. E. Mark Century control—*all* operator controls at the console—solid state components (no tubes, stepping switches or rotating parts)—temperature and humidity controlled—built-in computer for linear and circular interpolation.

Benefits:—increased efficiency and management control, reduced lead time, a permanent record in easily-stored form, low-cost quality control, reduced parts inventory, shorter set-up time and lower tooling costs.

Ask to have a LeBlond engineer stop and talk Tape-Turn, the machine on the floor instead of the drawing board. Or write for our new descriptive bulletin TT-1061 F.

LeBLOND of Cincinnati

The R. K. LeBlond Machine Tool Company, Cincinnati 8, Ohio

Leading the way in numerically-controlled turning.

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The Magazine of Automatic Manufacturing Operations

SEPTEMBER 1961
Vol. 8 — No. 9

AUTOMATION

A PENTON PUBLICATION

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around the triangle

QUICK-CHANGE ULTRASONIC TRANSDUCERS

Development of removable ceramic transducers has been announced by International Ultrasonics Inc. The transducers are fabricated of a lead zirconate titanate ceramic and are capable of operating continuously up to 300C at frequencies from 10 kc to 100 kc. Configuration of the transducer permits it to be bolted through the middle to horns, cleaning tanks, or any ultrasonic device, and easily removed. No bonding operation is required and electrical connections do not have to be soldered. Built-in heat exchanger fins are formed from metal casing, fitted as integral parts of the transducer assembly.

ELECTRIC HEATER STARTS AMMONIA PROCESS

Direct contact electric resistance heater is used to start up process that converts nitrogen and hydrogen to ammonia at Sun Oil Company's Marcus Hook plant. The process used involves compressing nitrogen and hydrogen gas to 4200 psig pressure and then passing the compressed gases over a catalyst. A 400-kw direct contact gas heater, with a heated length of 14 feet, is used in the start-up operation. The heater, developed by Hynes Electric Heating Co., raises the temperature level of the catalyst bed to 700F during plant start-up. Transfer of energy from heater to bed is accomplished by passing synthesis gas over the heater. About 20 hours are required for heating. This is followed by gradual reduction of electrical input to the heater. It finally is shut-off entirely since the process is exothermic.

DETECTS SPECKS

Sensitive new device can detect particles less than four millionths of an inch in diameter and a single particle among 1000 trillion other particles. The condensation nuclei detector, developed by General Electric Co., is sensitive to condensation nuclei—smallest airborne particles. The detector works by causing droplets to be formed around each nucleus. The droplets grow to microscopic size large enough to scatter a light beam. Measured electronically, the light scatter indicates the concentration of nuclei in the man made fog. Extreme sensitivity and the continuous operation which makes it possible are pointed out as unique features. Some of the applications noted have been in predicting useful life of certain electrical equipment on the basis of a single operation, monitoring air pollution, and adjusting carbon brushes on electric motors.

STAMP SIZE MEMORY PLANES

Cryogenic thin film memory plane the size of a postage stamp is produced by automatic control techniques. The new memory plane, produced by Federal Systems Division laboratory at IBM, consists of 135-cryotron devices built up in 19 layers of material. Forty bits of information are stored in 120 of the cryotrons; 10 cryotrons are used for access to stored information; and 5 cryotrons are in-line elements used to switch information from one memory plane to another. Key to this development is the technique which permits accurate duplication of the devices. By means of this technique microscopically thin layers of metals and insulating materials are automatically deposited on a glass substrate. The equipment used for deposition allows each layer of a metal or insulator to be sequentially deposited through 17 miscrosopically adjusted masks, or perforated metal sheets. Once the masks have been properly aligned, the process automatically produces duplicate super conducting memory planes with similar electrical and mechanical characteristics.

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BPA NBP

. . . Fluid Power news

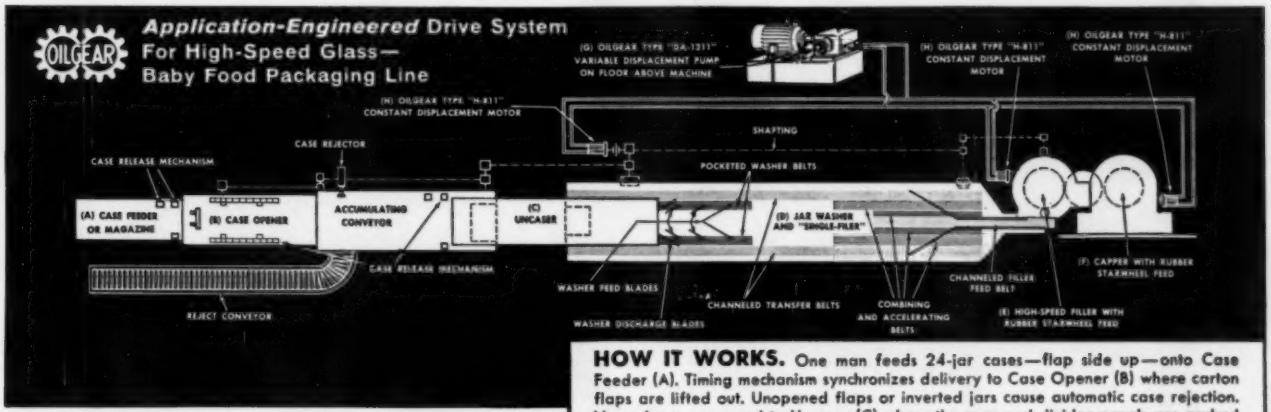
OILGEAR 40 Years of Fluid Power

REPORT NO. 11,303 From Oilgear Application-Engineering Files

HOW OILGEAR SYSTEMS *on Gerber's Integrated Glass Lines* BOOST OUTPUT—CUT COSTS

USER: *Gerber Products Company, Fremont, Michigan; Rochester, New York; Oakland, California*

DATA: To sharply reduce breakage, jam-ups, downtime, and labor costs in filling glass baby food jars at higher speeds, Gerber's Engineering Research Department developed the first fully integrated, high-speed machine for packaging foods in glass economically, under completely automatic control. *Drive Requirements for this multi-unit machine were outlined as follows:* 1. Complete synchronization of the seven integrated units through three drives—at the Uncaser, Filler, Capper. 2. Positive, precise, remote pneumatic control of operating speed that is instantly, infinitely variable from very slow to top speed while the machine is running. 3. Controlled acceleration and deceleration to prevent jars from tipping and jamming, eliminates spillage, reduces machine strain. 4. Compact, for maximum work area. 5. Independent operation of Filler and Capper drives to facilitate cleaning. 6. Trouble-free, dependable, long-life operation, immune to frequent sanitary washdowns, fully enclosed to prevent food contamination.


OILGEAR
Application-Engineered Drive System
For High-Speed Glass—
Baby Food Packaging Line
(G) OILGEAR TYPE "DA-1211" VARIABLE DISPLACEMENT PUMP ON FLOOR ABOVE MACHINE
(H) OILGEAR TYPE "H-811" CONSTANT DISPLACEMENT MOTOR
(H) OILGEAR TYPE "H-811" CONSTANT DISPLACEMENT MOTOR
(H) OILGEAR TYPE "H-811" CONSTANT DISPLACEMENT MOTOR
SHAFTING
CASE REJECTOR
CASE RELEASE MECHANISM
POCKETED WASHER BELTS
(A) CASE FEEDER OR MAGAZINE
(B) CASE OPENER
ACCUMULATING CONVEYOR
(C) UNCASER
(D) JAR WASHER AND "SINGLE-FILER"
(F) CAPPER WITH RUBBER STARWHEEL FEED
CASE RELEASE MECHANISM
WASHER FEED BLADES
CHANNELED TRANSFER BELTS
CHANNELED FILLER FEED BELT
COMBINING AND ACCELERATING BELTS
(E) HIGH-SPEED FILLER WITH RUBBER STARWHEEL FEED
REJECT CONVEYOR
WASHER DISCHARGE BLADES

HOW IT WORKS. One man feeds 24-jar cases—flap side up—onto Case Feeder (A). Timing mechanism synchronizes delivery to Case Opener (B) where carton flaps are lifted out. Unopened flaps or inverted jars cause automatic case rejection. Normal cases proceed to Uncaser (C) where the case and divider panels are pushed down and away from the jars. Uncaser deposits jars on transverse-channeled conveyor platens. Blades slide jars from channeled platens into pocketed belts which hold jars inverted through Washer (D). Jars are plowed from washer belt pockets to transverse-channeled combining and accelerating belts—moving 350 to 400 jars per minute . . . are then "shuffled" into the "Single-Filer"—550 to 650 jars per minute on a channeled belt to Filler (E). Rubber starwheels minimize breakage in feeding the 25-pocket Girdler Filler (E), and 16 twin-head Anchor-Hocking rotary Capper (F) . . . both custom-built for Gerber with center-to-center jar spacing for positive, smooth glass transfer between units. Smooth synchronization, cushioned acceleration and deceleration provided by the Oilgear Drive and Control System, combined with no jar-to-jar contact make possible the almost noiseless higher speeds and virtual elimination of glass damage . . . for if even a single jar or bottle is broken in food or pharmaceutical operations, a complete and costly shutdown, cleanup and inspection of the packaging line by quality control personnel is required.

SOLUTION: An Oilgear "*Any-Speed*" Drive, consisting of a Type "DA-1211" variable displacement pump and three Type "H-811" constant displacement motors—powers all elements of "The Gerber Integrated Glass Lines" to *meet and exceed originally specified drive requirements.* For maximum work area around the "Glass Line," prevention of possible food contamination, and use of an economical electric motor, the Oilgear "*Power-Pak*" is located on a different floor of the building. A compact control panel located at the Filler enables the operator to start, stop, jog, and instantly vary speed of the entire machine through an infinite range while the machine is running—thereby obtaining maximum efficiency for the consistency of the food being filled. The drive system automatically synchronizes the speed of all seven machine units. Operating speed ranges from 550 to 650 jars per minute—depending entirely upon the products being filled . . . *an increase of up to 23% over former conventional glass packaging methods.*

GERBER REPORTS—"*The major advantages of this newly developed equipment are: less shock and scratching of jars, which reduces damage; substantially higher speeds: more thorough washing; lower maintenance cost and automatic control of all segments of the line.*"

Due to the smooth, cushioned application of power, even at higher speed, reduced glass damage and the resulting reduction in downtime, maintenance and labor costs with this Oilgear-powered, Gerber-designed machine, an expanded installation program of these "Integrated Glass Lines" is now under way at all Gerber plants.

"PLUS" features of this Oilgear Drive and Control System are: dual, automatic, built-in hydraulic and electric overload protection—stops the machine in event of jamming or malfunction . . . automatic hydro-dynamic braking . . . direct torque reading at the control panel . . . constant pressure and flood lubrication with continuous power fluid filtration . . . complete flexibility for location of drive and control components . . . fast, easy installation . . . standard drive and control components sealed against washdowns . . . lower power consumption—using only power in proportion to work performed. There are many more—but these alone should be sufficient proof why designers and builders of machinery are turning to Oilgear, and say . . .
"*for the lowest cost per year—it's OILGEAR!*"

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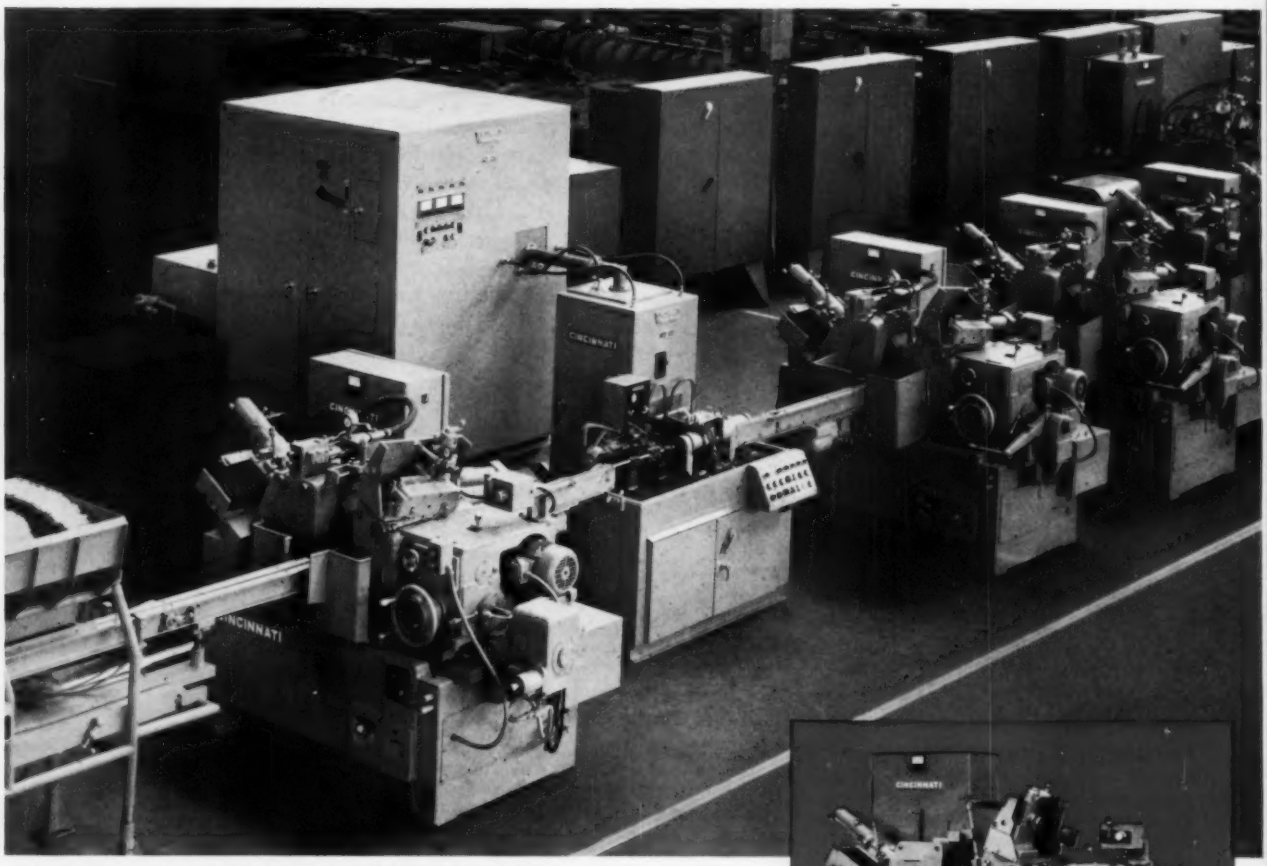
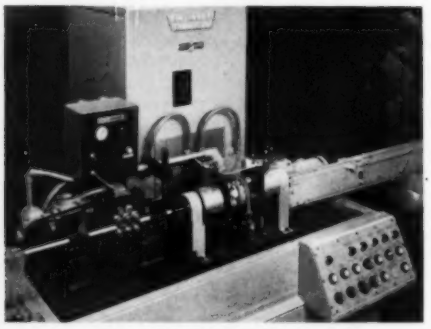


Continuous production of shock absorber piston rods is achieved on this CINCINNATI Precision Production Line. Rods are hardened and ground at the rate of 960 per hour. Hardened and ground diameter is indicated by heavy red line in above drawings.



CINCINNATI INDUCTRON Induction Heating Machine shares the spotlight with five CINCINNATI FILMATIC Centerless Grinders.

BUILDERS OF PRECISION GRINDING MACHINES: CENTERTYPE • CENTERLESS • ROLL •

THE CINCINNATI MILLING MACHINE CO., CINCINNATI 9, OHIO

hardened and ground on

CINCINNATI
Precision Production Line!

Nine sizes of CINCINNATI FILMATIC Centerless Grinding Machines give you a choice of the right size for your work. Catalog G-727-1-D covers the Centuramic line.

Shortest and fastest trip to the point of perfection . . . the one taken by shock absorber piston rods in this CINCINNATI Precision Production Line. From the loading unit at the extreme left, work traverses first through a CINCINNATI FILMATIC Centerless Grinder for the primary grinding operation, then through an INDUCTRON® Induction Heating Machine for hardening of the center section. Four more Centerless Grinders complete the grinding operation, the finished parts emerging at a rate of 12 linear feet per minute or 960 per hour.

CINCINNATI FILMATIC Centerless Grinders are ideal for production line duty. FILMATIC grinding wheel spindle bearings never wear out or require adjustment. Infinitely variable regulating wheel speeds permit close adjustment of speed to suit station-to-station work traverse. Simple swivel plate adjustment aligns work rest and regulating wheel unit with conveyor. Unobstructed access at rear of machine facilitates setup and corrective adjustments. Many other feature-advantages are outlined in attractive literature.

Cincinnati Milling offers many types of products to give you unmatched completeness of production equipment. May we hear from you?

CINCINNATI FILMATIC®

CHUCKING • MICRO-CENTRIC • PRODUCTION LINES

CINCINNATI®
GRINDING MACHINE DIVISION

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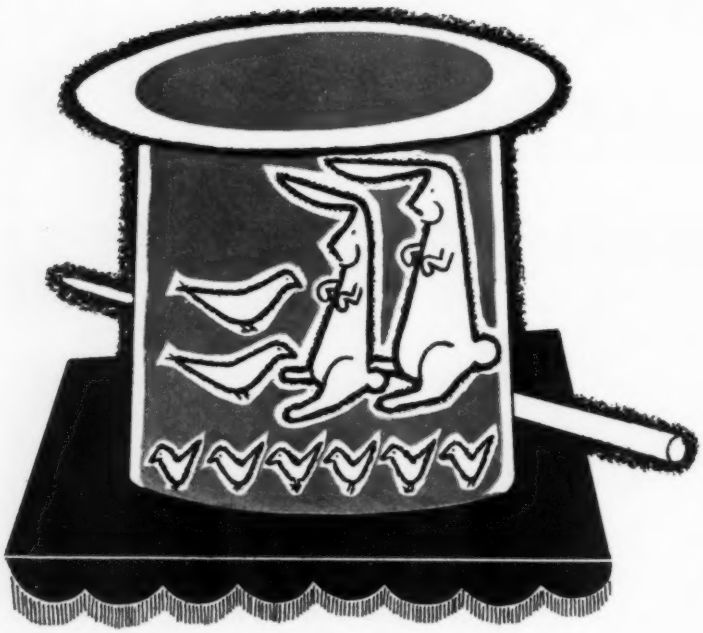

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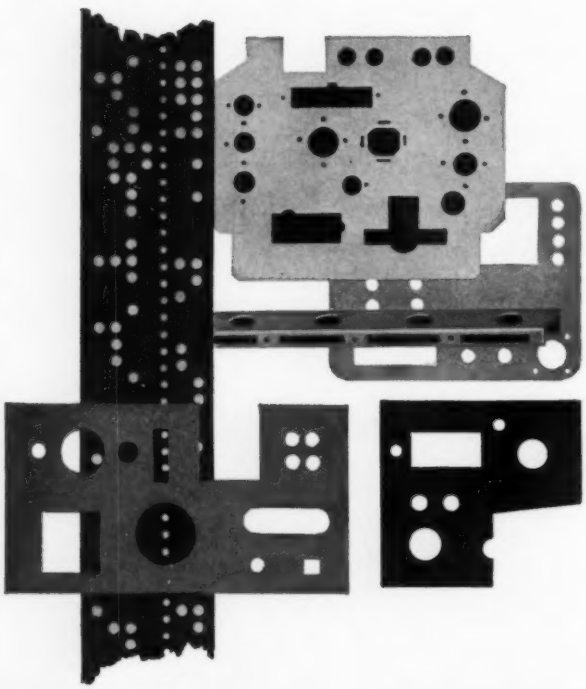

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For metal fabricators, the WIEDEMANN is the *right equipment* to pierce plates and panels on a short run and medium production lot basis. A WIEDEMANN makes possible the production of 1-10-100-1000 or more parts—economically, accurately and efficiently—with a minimum of preparation.

Turrets carry all punches and dies ready for immediate use. Work is positioned mechanically to rapidly and accurately locate and pierce holes of many sizes and shapes. This combination eliminates layout, setup, handling, expensive tools and most costly factors which are necessary in other methods.

The new WIEDEMATIC is the latest and most efficient WIEDEMANN turret punch press. This machine is designed specifically for highspeed short and medium run production. Tool selection, work positioning and piercing are fully tape-controlled. Engineering changes, too, are readily made by simply substituting desired information on the tape.

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Circle 667 on Page 117

automation outlook

By **ROGER W. BOLZ,** Publisher and Editorial Director

WE HEAR A LOT about computers doing yeoman duty in the way of decision making in many important areas of management. Seems to be plenty of imagination and wishful thinking here. Anyone that figures a computer will automatically make good decisions or accurate decisions or replace creative management planning should take another look.

Although computers facilitate the processing of any data reducible to symbolic logic, they cannot produce better answers unless some rather well-developed empirical methods have been formulated for arriving at "good" answers now. From a careful look at much of the material stressing optimum mathematical solutions, we still have a considerable way to go.

In his **FIER** lecture of 1960, Jay W. Forrester of **MIT** pinpointed a number of misleading "guideposts" that unfortunately have been widely accepted. One is that the distinction between policy and decision has been obscured. He emphasized the importance of utilizing models of industrial systems for policy rather than decisions—policy which governs how the decisions are made. His words, ". . . present-day emphasis on the management game as a training device arises from a misplaced concentration on decisions rather than policies."

Few managements make clear-cut decisions based on a clear-cut fact finding approach. Most management decisions still are and must be a process of progressive commitment to a course of action. Poor decisions are often made unusually good by unforeseen circumstances and some unusual talent along the line. Many good decisions are nullified by lack of talent or insight necessary to realize the possible ends looked for. Changing conditions may call for some fast creative action along lines not previously attempted or studied.

Some plain and factual study of the opportunities, however, will show that computers hold tremendous promise for aiding management in its decisions especially where it is possible to plot a course of action against timely information analysis rather than ancient history. However, it does take managers with broader experience, better insight, deeper understanding, and more analytical ability than were commonly needed in the past.

ONE OF THE GREATEST innovators of all times, Thomas A. Edison, is now included in New York University's Hall of Fame for Great Americans as the immortal symbol of our technological age. At the June 4 unveiling of the bronze bust of Edison, David Sarnoff, chairman of **RCA**, highlighted Edison's greatest contribution—modern research—the systematizing of the quest for knowledge. One key formula followed by the great inventor holds a message for industry today, "There's a way to do it better—find it."

automation outlook

ACCORDING TO THE NOTION, still popular in some areas, that technological change creates long-run unemployment, it seems that by now just about nobody should have jobs. Emerson P. Schmidt, U. S. Chamber of Commerce director of economic research, quotes some historically interesting figures in his recent statement to the House Subcommittee. Here is one of a number of such perspectives:

"The manufacture of boots and shoes offers some very wonderful facts in this connection. In one large and long-established manufactory the proprietors testify that it would require 500 persons, working by hand processes, to make as many women's boots and shoes as a hundred persons now make with the aid of machinery—a displacement of 80 per cent."

The date—1889—and the source—a book, "Recent Economic Changes" by David A. Wells. Wells was the first economist of what is now the BLS.

AFTER YEARS OF DOWNWARD DRIFT, textile manufacturing appears to be in the midst of an important change. Textile manufacturers and machinery makers have at last become active in technological improvements of significance. Important developments in process involve automating certain tedious and slow operations that have long remained unchanged. Most significant, however, is the trend toward concentration on development of entirely new concepts in processing.

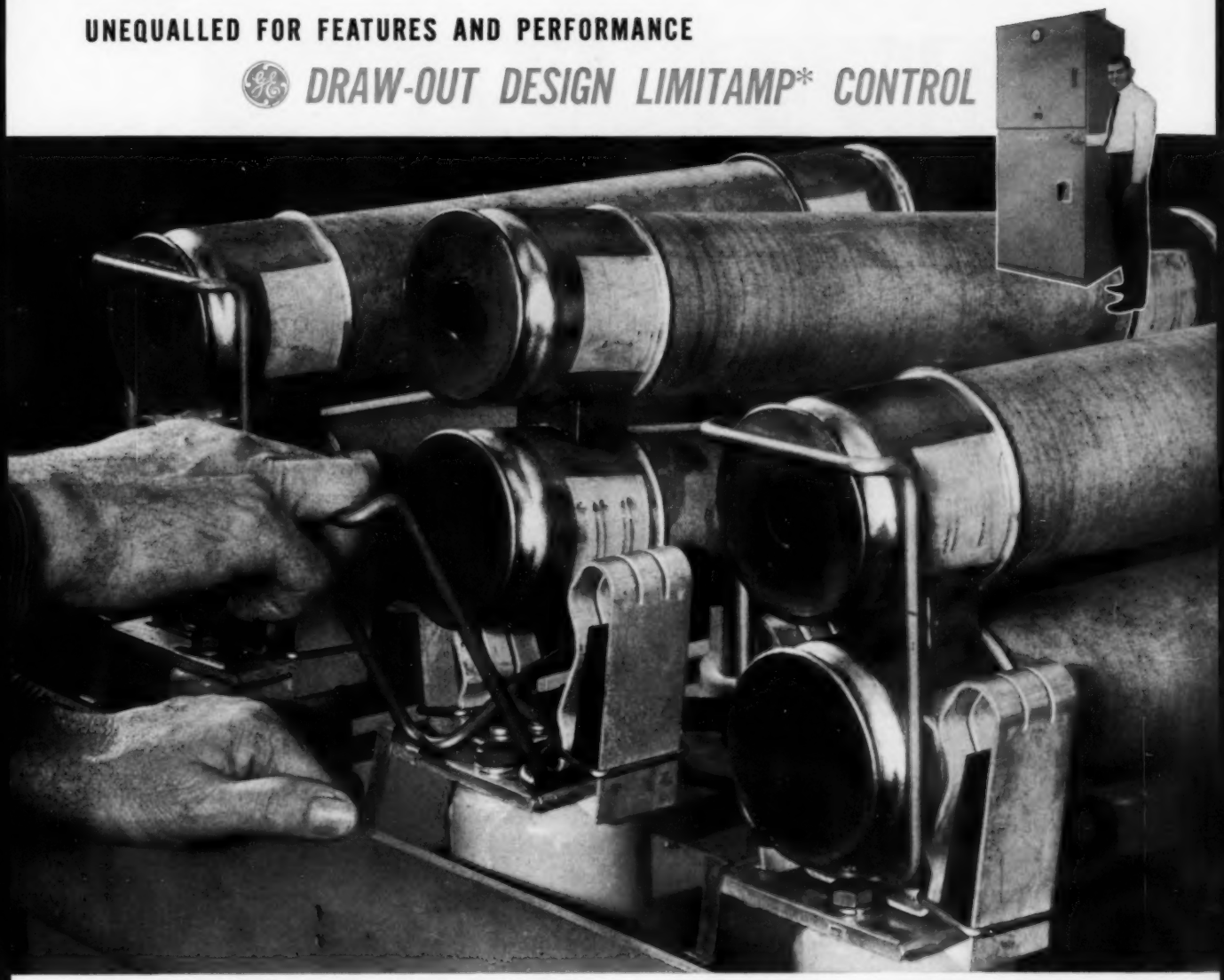
HUMANS MUST STILL DO their own thinking according to J. W. Schnackel, vice president and general manager of Univac. No machine is now in production or on the design boards that will do it for them. The central information tool is still the punched card. Univac is spending more on punched card research this year than it has in the past twenty to meet the demand for fact gathering. Use has been rising some 10 per cent yearly.

POPULAR DISCUSSION in Government circles regarding retraining of displaced jobholders appears to disregard one very important item. Only a small percentage of the available labor force give much thought or effort toward improving their mental and physical capabilities voluntarily to compete in the market for better jobs. For free enterprise to work effectively for jobholders as well as industry, basic retraining work will have to begin at the heart of the problem: creating fuller understanding and inspiring continuing re-education efforts among a major percentage of blue collar workers. There is need for a new look at the old parable of the talents.

WITH ALL THE TALK about the growing yearly R&D expenditure, one facet appears to be lost in the shuffle. Research in new manufacturing methods and systems, the key to profits and vitality, is apparently of such insignificance as to merit little formal recognition. Hardly one-fourth of the companies surveyed recently have any formal manufacturing research program with budgeted funds and specific ends being pursued.

UNEQUALLED FOR FEATURES AND PERFORMANCE

DRAW-OUT DESIGN LIMITAMP* CONTROL



INTERRUPTS IN 1/2 CYCLE

...protection when you need it—with Limitamp control

Here is performance you can count on ... to start, stop, and protect your motor under *your* environmental conditions!

General Electric's draw-out Limitamp control, rated 2300- to 4600-volts for a-c motors up to 3000 hp, interrupts in the first ½ cycle. Current is limited in the first ¼ cycle. EJ-2 fuses—the standard of excellence—give you this dependable short-circuit protection.

Performance of the draw-out contactor is outstanding under all load conditions—from small motors running light to large motors at "locked rotor." A new blow-out structure and an improved arc chute with superior extinguishing action provides this improved performance. What's more, the new Limitamp contactor meets a 60-kv base impulse level.

Complete design coordination and exhaustive testing in General Electric's high voltage laboratories of bus, cable, current transformers, contactors, fuses, insulators, and overload relays means top protection for men and equipment!

Ask your G-E sales representative about other advanced-design operation, installation, and maintenance features of new Limitamp control. Or, write today to Section 783-26, General Electric Company, Schenectady, New York for descriptive Bulletin GEA-6893.

Industry Control Dept., Salem, Va.

* Reg. Trade-mark of General Electric Co.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 668 on Page 117

Control and/or measure FLUID DENSITY

automatically/directly/continuously

THE HALLIBURTON DENSOMETER is a rugged, low-cost instrument designed to give direct, continuous physical measurement of fluid density, independent of any other fluid property. The Densometer, available in two models, detects any change in density of the fluid passing through it and transmits a pneumatic or electrical signal to key the indicating, recording, or controlling equipment used in conjunction with the device. The versatile Densometer is now in service handling such varied slurries as cement, copper ore, gypsum-water, milk of lime, paper coating, and many others.

TECHNICAL SUMMARY OF OPERATION

Fluid flows through a flexible hollow beam in the Densometer. Changes in weight (density) of the fluid are transmitted through a null-balance system, triggering a pneumatic signal indicating the extent of the change. Response time of the unit is two seconds. These units may be used in fluid systems up to 200°F., 50 psi, ranging from 1.0 to 2.0 Specific Gravity or from 6 to 21 pounds per gallon of fluid.

MODEL 59 DENSOMETER incorporates a ¾" U-tube arrangement and is generally used for sampling operations or mobile installations. The stainless steel U-tube may be used in place of the standard glass tube if desired. A small pump provides a continuous fresh sample at a velocity sufficient to support suspended particles.

MODEL 60 DENSOMETER is the larger unit, incorporating a straight 2" tube, and is usually recommended for systems requiring either large samples or total flow measurement. The center-supported tube permits larger suspended solids to flow through the unit without excessive abrasion. Gravity flow is sufficient with this unit in most applications. Larger diameter models may be furnished to accommodate greater flow specifications.

IF YOUR PRODUCT MIX CONTROL IS CRITICAL, investigate the Halliburton Densometer for accuracy within 1% in recording, indicating or controlling fluid densities. See your Halliburton man for all the facts.

SPECIAL PRODUCTS DIVISION

Halliburton
COMPANY · DUNCAN, OKLAHOMA

Circle 669 on Page 117

AUTOMATION news

Today's events and developments in the field of automation

Closed-Loop System Controls Giant Still

CLOSED-LOOP, process control system has been installed to control a 140,000 barrel-a-day crude-oil distillation unit, the world's largest, at American Oil Company's Whiting, Ind. refinery. Ten product streams are distilled from the crude-oil run through the unit. The control system developed by International Business Machines Corp. is built around an IBM 1620 solid-state digital computer. It is coupled to a large random access memory storage and an input/output system for linking the crude unit instruments and the computer. The computer will continuously analyze operating conditions, determine optimum settings, and automatically adjust controllers to maintain optimum operations as process conditions vary. It can scan 250 process instruments, and will continuously adjust 24 control instruments in closed-loop control.

OPERATOR'S CONSOLE for closed loop computer process control system is shown posed temporarily with crude-oil distillation unit in background. The 140,000-barrel-a-day unit at American Oil Co. will be under continuous control of a computer system that will analyze operating conditions and automatically adjust process controllers. By use of the console, operators may interrogate the computer about process conditions and feed new information to the computer.

An operator's console provides means to make inquiries of the computer and to insert information into the computer such as product specification changes or latest laboratory results. The computer will automatically determine and make necessary control changes.

For the past year the crude unit has been linked through a monitoring system to an IBM 704 computer in a computing center more than a mile away. Now the crude unit will be under continuous computer control, seven days a week around the clock, instead of periodic computer guidance of the operator on a time sharing basis.

OPERATOR is pointing at one of the process controllers mounted on a graphic control panel for the giant crude still. Just to the right of the controller is a motor driven control set-point device. In response to instructions from the computer, the control device will make set-point corrections for optimum operation.

Handling Systems For Ship Cargoes

CARGO handling will be automated on three new Grace Line passenger/cargo vessels being built by the Shipbuilding Div., Bethlehem Steel Co. The automatic equipment will include platform-type cargo elevators and integrated pallet conveyor systems. The two cargo elevators aboard each ship will handle pallets, cars, and general cargo in conjunction with overdeck gantry cranes. Three holds on each ship will be equipped with automatic pallet handling systems.

When incoming cargo arrives, an operator at a master control station will select the hold level at which the particular load is to be delivered. When the cargo reaches this level, it will be automatically discharged onto a conveyor platform. An indicating system located on the master control station will show the location or in-motion condition of each elevator at all times. Safety and personnel-warning devices will be installed on the elevator-conveyor pallet handling system to guard against malfunctioning or accident. General Electric Co. has ac-

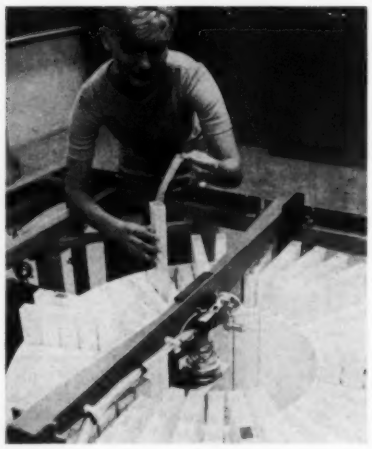
cepted responsibility for the design, manufacture, co-ordination, and installation supervision of the handling systems. Lake Shore Inc. will supply the mechanical equipment.

Processing Time Cut By Nationwide Order System

AUTOMATIC order-processing system has been installed by the apparatus products group of Westinghouse Electric Corp. to give faster delivery to 15,000 customers across the nation while closing some field warehouses and reducing stocks at others. The process, from sales order to shipping order, now takes only 30 minutes compared to the previous 6-day period.

The apparatus products group markets stock items such as motors, distribution transformers, and meters; and custom-made equipment such as turbine-generators, power transformers, and large switchgear. Complete customer information, inventory, and cost data on some 42,000 of the stock items manufactured by nineteen plants are stored in the memory unit of a computer. The computer is a dual IBM Ramac 305, having storage capacity for 20 million digits of information. It is linked to a Westinghouse private teletypewriter network connecting some 90 sales offices, 26 field warehouses, and 19 plants.

More than 1600 orders are processed daily through the center in Pittsburgh. The incoming information is sent in brief coded form, then converted from paper tape to punched cards and processed through the computer. The computer locates the stock at the warehouse nearest the customer, updates inventory records, and punches out statistical and invoice cards. After the cards are used to produce invoices on an accounting machine, the data is converted to tape and transmitted to the warehouse where it is received on teletypewriters which produce the complete shipping orders. The invoices are mailed directly from Pittsburgh to the customers.



DOCUMENT FILE for information system that stores and retrieves any one of millions of images of printed or typed pages or photographs within five seconds. Images are optically reduced and transferred to film strips for storage, and address and identifying information for each image is recorded on a punched card. Documents are also referenced in a magnetic index. This index can be searched to select punched cards for desired documents. Image location of a desired document is then punched in an aperture card containing an unexposed film insert. When this card is inserted into a document file, the film strip containing the desired image is moved into position and the image is transferred to the aperture card by ultraviolet exposure and a dry heat developing process. The aperture card may be used to project the image on a screen or print out an enlarged photograph. International Business Machines Corp. developed this prototype information system, called Walnut, for the Central Intelligence Agency.

Metal Show Scheduled for Detroit

PLANS are near completion for the 43rd National Metal Congress and Exposition, sponsored by the American Society for Metals. The event will take place October 23-27 at Cobo Hall, Detroit. Some 30,000 metalworking executives, design, product, and metallurgical engineers, and production personnel are expected to attend.

One of the highlights will be the Materials Comparison Center, a 12,000 sq ft exhibit area that presents seven engineering materials groups for comparison and evaluation as to specific properties. Scores of sample parts, test specimens and graphic materials will be brought together for comparison. Materials groups to be compared include: Wrought ferrous, wrought nonferrous, cast ferrous, cast nonferrous, special purpose, nonmetallic, and composite.

Following the concept introduced by ASM last year, exhibitors will be restricted to eleven metalworking categories: Steel, Nonferrous; Nonmetallic; Nuclear; Tool Materials, Cutting Off & Forming Equipment; Industrial Heating; Cleaning & Finishing; Welding & Joining; Testing, Inspection, Control & Research; Metals Production & Casting; and Parts Forms & Shapes for Design & Application. Approximately 275 exhibitors are expected.

Ten technical societies and trade associations will participate in the technical program which includes 62 half-day sessions and 200 technical papers. Further details are available from society headquarters, Metals Park, Novelty, Ohio.

CONTRACT in the amount of $162,141 has been awarded to Philco Corp. by the U. S. Army Signal Supply Agency to develop automatic production equipment for the manufacture of silicon surface alloy transistors. Primary part of the program will be toward the design and manufacture of high speed automatic lead attachers. The application of automation techniques to the silicon transistor lines is expected to improve product uniformity and reliability as a result of precision-controlled processing.

Airline Reservations to Be Checked Electronically

ELECTRONIC AIRLINE reservation system that makes up-to-the-second flight and passenger information instantly available will

NEW CONTROL STOPS AUTOMATIC MACHINE OPERATIONS IN CASE OF MALFUNCTION!

TRANSISTORIZED SENSOMATIC CONTROL SAVES MAN HOURS, PREVENTS MATERIAL WASTE, MACHINE AND TOOL DAMAGE

Newark, N. J.: A new line of transistorized controls called Sensomatic has been developed by Weldotron Corporation. Sensomatic is a low-cost, easy-to-install digital control for monitoring automatic machine operations. It will stop the machine immediately upon detecting malfunctions such as misfeed, improper positioning or improper parts transfer, buckling, end of material, etc., thus preventing tool and machine damage and material waste. Add to this the savings in man-hours and the fact that faster operation is possible because it reacts quickly, and it is easy to see why Sensomatic will surely cut costs in your automatic machine operations.

Sensomatic is ruggedly constructed with no moving parts in operation. It requires little power and features fail-safe, dust free circuitry encapsulated in epoxy resin for maximum resistance to shock, moisture and other detrimental environmental conditions.

Proven performance

For some time many large manufacturing companies such as Scovill Mfg. have been using Sensomatic units in actual production operations. Records have proven the success of the units.

Sensomatic controls are available in several models. To learn which model is best suited to your operations, please write today to Weldotron Corporation, 911 Frelinghuysen Avenue, Newark 14. N. J.

SENSOMATIC Model 1200 Will Monitor Operations of up to 12 Stations

The Sensomatic 1200 Multi-Station Detector will monitor operations of up to 12 stations. If a malfunction occurs at any one station, the machine is instantly stopped and a visual signal alerts the supervisor. The exact location of the trouble is pinpointed by individual indicator lights.

The 1200 is supplied with 4 modules but eight others may be added as requirements increase. Economical use of the modules is possible because they are interchangeable on all Model 1200's.

WHERE SENSOMATIC CONTROLS CAN BE USED

Waterbury Farrell and Baird Eyelet Presses • Punch Presses • Press Brakes • Shears • Forging Machines Die Casting Machines • Thread Rolling Machines • Cut Off Machines • Screw Machines • Automatic Lathes Riveting Machines • Sorting Machines • Four Slide Machines • Zipper Machines and many others

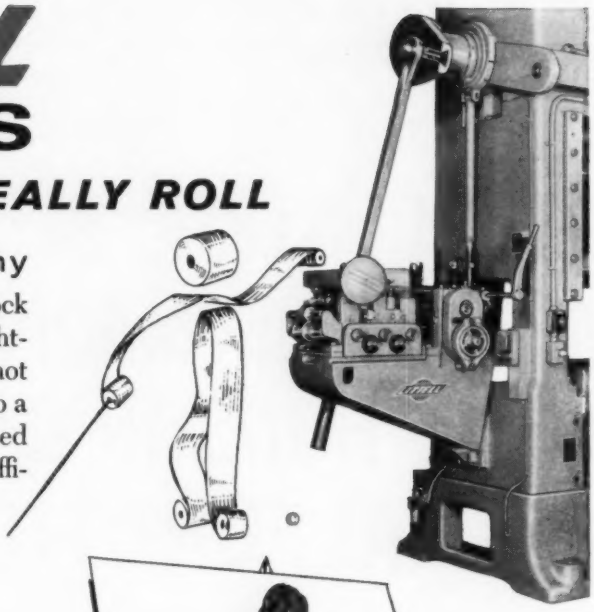
Circle 670 on Page 117

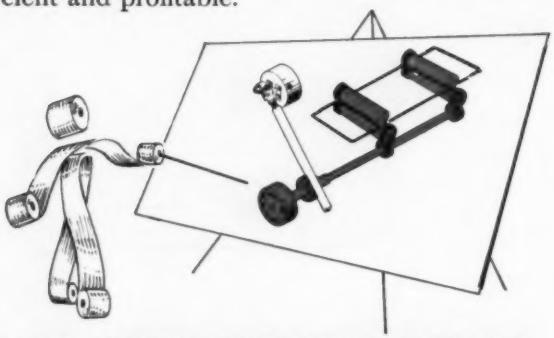
LITTELL
ROLL FEEDS

Make Press Production REALLY ROLL

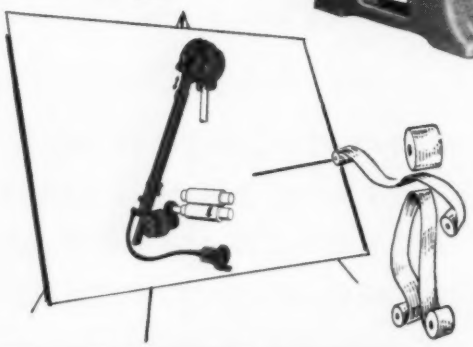
Old Pro "Coily" Points Out Why

"Coily" has been around press rooms since coil stock came into the picture. He has seen Littell Straighteners and Feeds widely copied, in design, (but not in performance) time after time. He points here to a few of the new advanced design Littell Roll Feed features that make punch press operation more efficient and profitable.

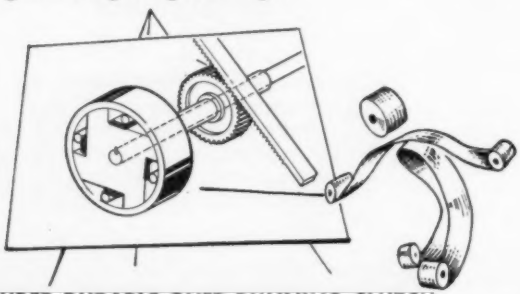




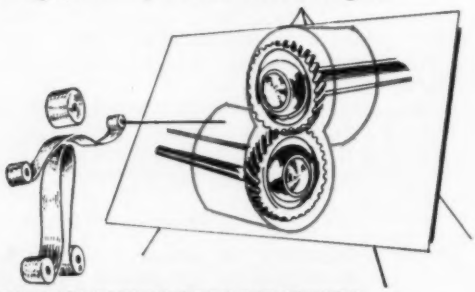
GEARS AND ROLLS ARE PRECISION CONTROLLED
Littell Rolls and Gears respond to control because they are light in weight. With less inertia to overcome, these strong, yet light rolls and gears start easy, go faster, and stop quickly. Big, new type disc brakes further assure the control that means accurate feeding in the higher speed ranges.



LITTELL MICRO RUNNING ADJUSTMENT
enables the punch press operator to adjust feed length plus or minus ¼" while press and feed are running. A big help in setting up progressive dies requiring extremely accurate feed lengths.



SUPER DURABLE OVER RUNNING CLUTCH
Thanks to the exclusive Littell carbide cam construction that Coily points to, not a single clutch of this type has worn out in ten years of operation!



"CUSTOM BUILT" GEAR HOUSINGS
permanently hold Littell spiral gears in perfect alignment because each gear housing is specially machined for the individual spiral gears it seals in oil and protects. A Littell sustained accuracy feature.

2 New Bulletins For Punch Press Operators

Bulletin A-11
Describes Roll Feeds
For OBI Presses

Bulletin A-15
Describes Roll Feeds
For Straight Sided Presses

For free copies, address your request now.

F. J. LITTELL MACHINE CO.

4105 N. Ravenswood Ave., Chicago 13
District offices: Detroit, Cleveland

ROLL FEEDS • SHEETING LINES • STRAIGHTENING AND FEEDING MACHINES • REELS AND CRADLES FOR COIL STOCK

be used by Delta Air Lines reservation agents in 66 cities. The IBM Tele-processing network will link almost 300 remotely located agent terminals to a powerful computer center in Atlanta. System will handle more than 2,800 complete airline reservations an hour for any of almost 600 daily flight departures.

When a customer requests space for a specific date between cities, a Delta reservations agent will insert a flight card in the agent set and press buttons to query the computer on seat availability. The computer will search for the appropriate flight records and transmit, back to the agent set, the latest availability information. This will be displayed for the agent by lights. When the agent sells a seat, he will press several buttons and the computer center will update the seat inventory for that flight. Special instructions to agent sets from the computer (such as flight information) will be printed out on the console keyboard.

Reasons for Scale Inaccuracies Cited

CONSERVATIVE estimates put the cost of weighing inaccuracies at hundreds of millions of dollars annually states the Scale Manufacturers Association. One weights and measures supervisor cited an instance in which a bakery lost several thousand pounds of dough a month due solely to lack of proper care of its scales. To help others avoid such losses, the Scale Manufacturers Association has reported the most frequent causes of weighing mistakes as compiled from a recent survey by the Association.

Described as the "Seven Deadly Sins Against Weighing Accuracy" are: 1. Maltreatment. 2. Improper scale for weighing job. 3. Improper installation. 4. Lack of level and sturdy supports for small scales. 5. Lack of, or infrequent testing. 6. Lack of proper maintenance. 7. Carelessness and poorly trained operators.

Noted as due to maltreatment is damage done by overloading scales. Some scale people also say a scale should not be used to weigh a load less than 5 per cent of the scale's full capacity. In most states, for instance, weighing of less than 1000 pounds on a 30,000 pound or larger vehicle scale is prohibited simply because the large components are not tuned for small load sensitivity.

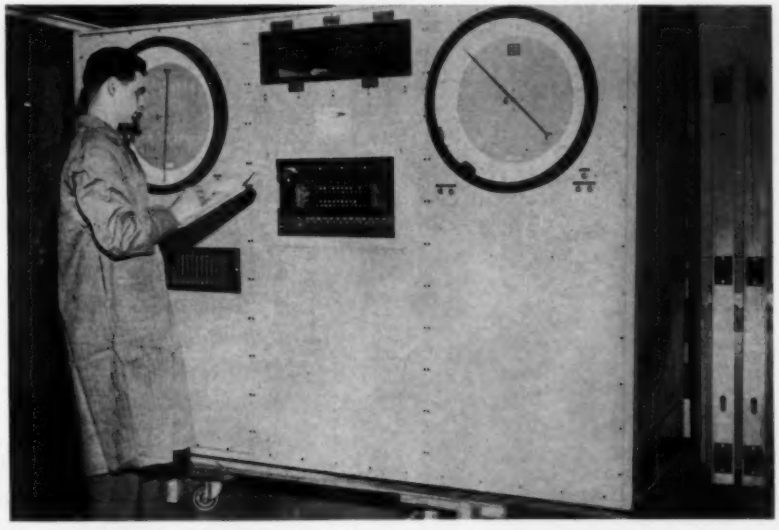
Further comments pointed out that many large capacity scales must be assembled at the site, but even the very best scale will not function satisfactorily unless foundations, approaches, and installation are proper. Small portable scales also require proper support to avoid out-of-level weighing except for a few types designed to operate satisfactorily in out-of-level condition. Frequent testing by local service agencies, scale owners, and/or operators is recommended in addition to official weights and measures checks.

INSTRUMENT SOCIETY OF AMERICA will hold its 16th annual conference and exhibit September 11-15. The conference will be centered in the Biltmore Hotel, with the exhibit located in the Memorial Sports Arena in Exposition Park, Los Angeles. Some 300 authors will cover the latest progress in instrumentation technology in 80 technical sessions. Further details are available from ISA headquarters, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

PLANTS to automatically produce high purity nitrogen in gas or liquid form, are being produced at Superior Air Products Co. The plants produce nitrogen of 99.999 per cent purity in volume up to 100,000 scfh. Nitrogen gas is available from the plants at a pressure suitable for distribution. A portion of the output is taken as liquid and stored for peak-loads and turn-around. Output of a plant increases or decreases automatically to meet demand.

Computer Indexes Documents Automatically

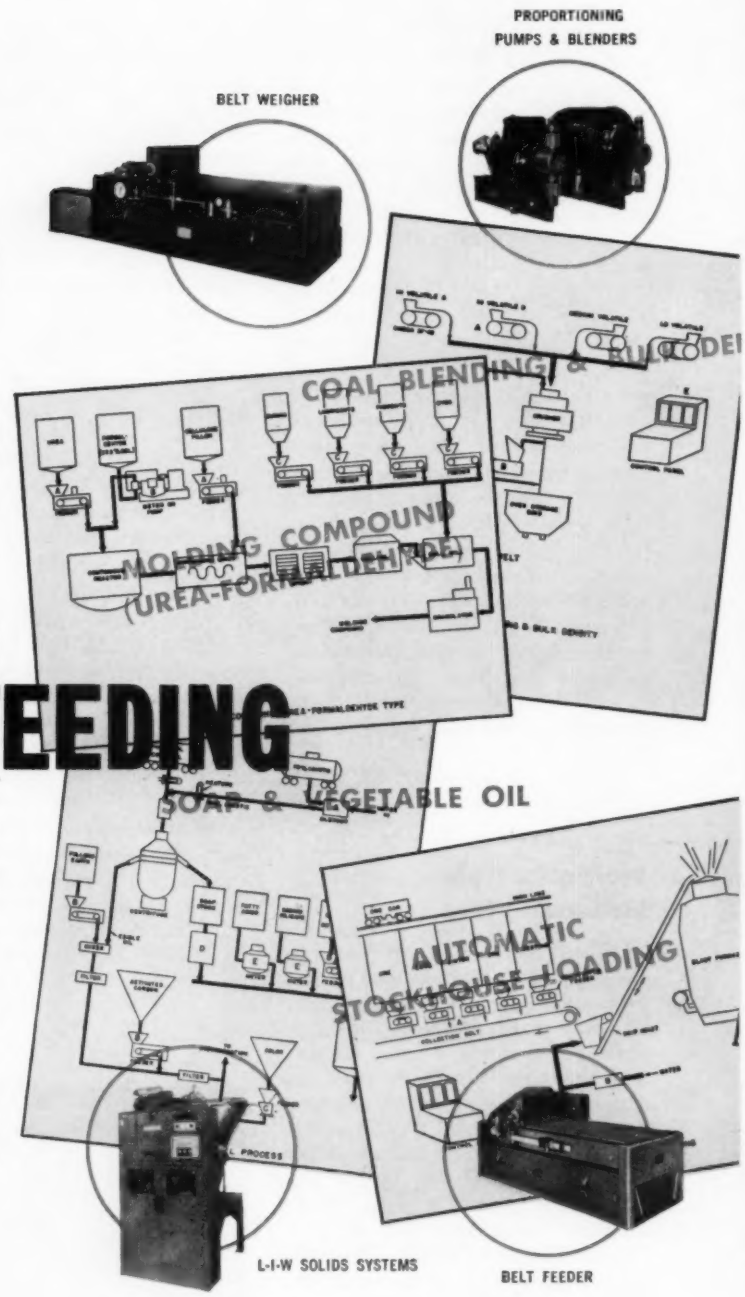
DOCUMENTS can be automatically indexed according to important words in their titles by an electronic digital computer at Bell Telephone Laboratories. Titles are fed to an IBM 7090 computer on punched cards, along with other cards containing the names of authors and identification numbers. The computer is programmed to scan these cards, reorganize the information, and print out a *Permuted Title* subject index. Each significant word of a title appears as a key word in the index, but the computer is instructed to ignore unimportant words. Each key word is listed alphabetically at the index position in context with the other words of the title. A title is progress-



DATA PROCESSING UNIT was designed for a steel pipe mill by Hammarlund-Automation Div., Telechrome Mfg. Corp. The system automatically weighs, measures, and stencils heavy pipe and stores production data. It presents quality control information with computer speed and accuracy.

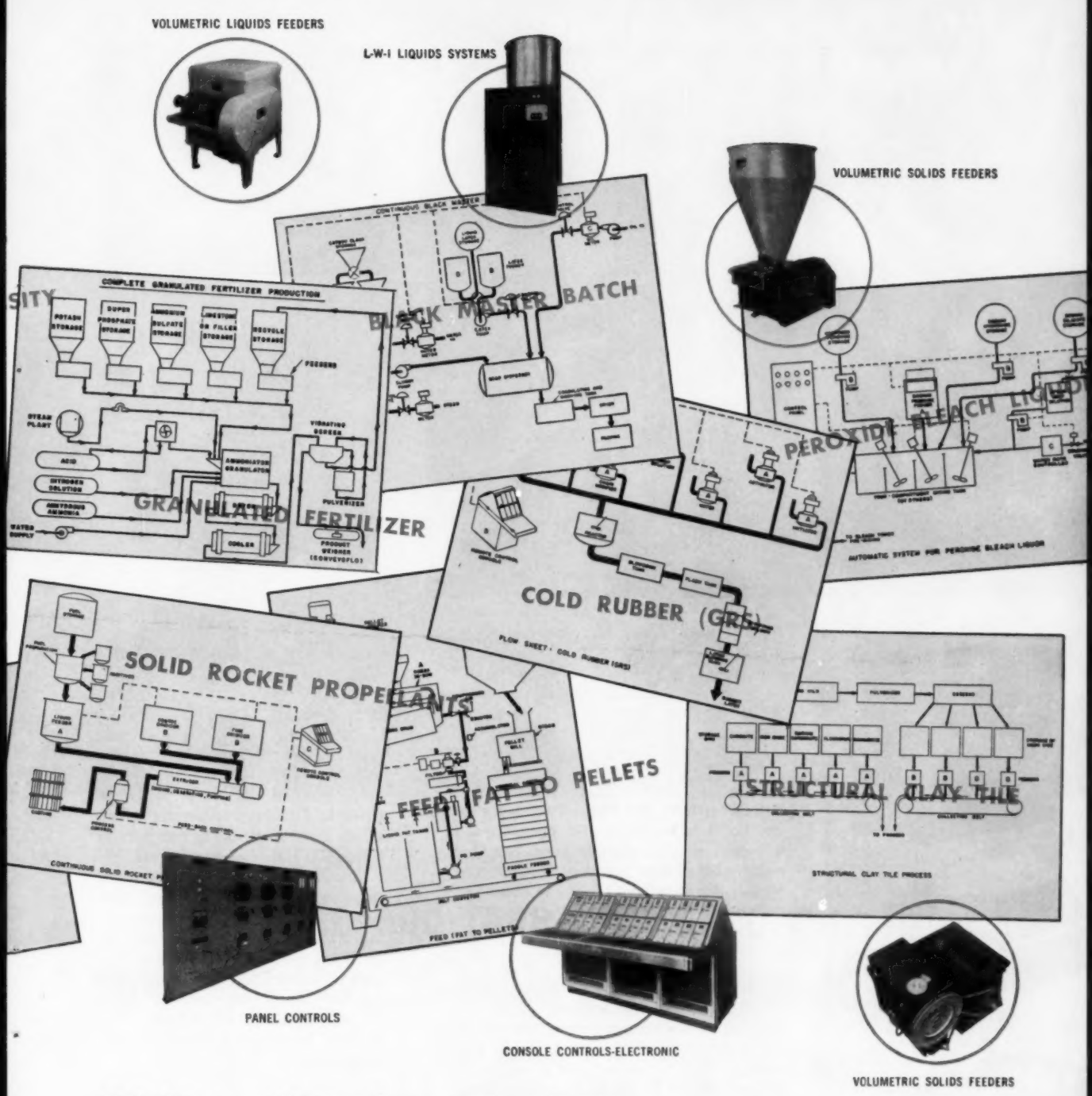
B-I-F

WHEREVER AUTOMATIC, CONTROLLED FEEDING OF LIQUIDS AND SOLIDS IS INVOLVED



Controlled feeding is a B-I-F specialty . . . whether it involves a single unit or a fully integrated system with provision for remote control. Thousands of installations throughout the chemical processing industries prove B-I-F's ability to handle chemicals of all kinds . . . including corrosive, toxic or hazardous types.

B-I-F has over 30 years of actual field experience in controlled feeding systems for solids and liquids. And . . . B-I-F manufactures the most complete line of volumetric and gravimetric feeders. The resulting application flexibility can give you a performance-proved system . . . based on your most exacting needs.



Reliability . . . precision control . . . accuracy . . . these are the keys to profitable batch or continuous processing. No one type of feeder or feeding system can meet every processing requirement. B-I-F's application knowledge assures the exact equipment for end product quality . . . minimum production cost . . . minimum waste!

B-I-F Industries

A DIVISION OF THE NEW YORK AIR BRAKE COMPANY

METERS • FEEDERS • CONTROLS / CONTINUOUS PROCESS ENGINEERING

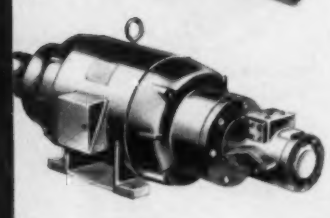
YOU NAME IT! When it comes to controlled feeding of liquids and solids, a B-I-F specialist is ready to recommend and furnish estimates. See Chemical Engineering Catalog or Sweet's Plant Engineering File for your nearest B-I-F representative . . . or write **B-I-F Industries, Inc., 527 Harris Avenue, Providence 1, R. I.**

Circle 672 on Page 117

BURGMASTER USES THESE VICKERS COMPONENTS

POWER PACKAGES—A complete Vickers 30-gallon hydraulic power supply was custom-designed and built for this machine. Vickers offers standard and custom power packages to meet every type of application need. Get details from your Vickers application engineer.

DIRECTIONAL VALVES—Two types of directional valves—solenoid operated and solenoid controlled, pilot operated—are used on this Burgmaster machine. The complete Vickers line of two- and four-way directional control valves is described in Catalog 5001C.



MINIATURE DIRECTIONAL CONTROLS—Series D1L two and four-way valves are designed for low volume systems, are suitable for operation to 1000 psi and have 2 gpm capacity. Low current a-c and d-c solenoids are available in all standard voltages. Write for data sheet D1L-1.

MOTOR PUMPS—A 5 HP, double-end motor pump is used on this Burgmaster. The complete Vickers motor pump line offers single, double, two-pressure and two-stage pumps. Use of these motor pumps conserves space and eliminates alignment problems between pump and motor. Details are available in Catalog 5001C.

VICKERS®

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1536 • Detroit 32, Michigan

Circle 673 on Page 117

9794

MAGNETIC FIELD SENSING devices will operate in broad temperature ranges from −40 to +100 C and are designed for continuous operation at 85 C. Produced by F. W. Bell Inc., the Hall-effect devices can be used in multipliers, transducers, and magnetic circuits. They can detect changes in magnetic flux density, changes in the angle between the magnetic flux and the plane of the device, or changes in current input to the device. The transverse field device (rectangular) measures 0.500 inch in length, 0.130 inch in width, and 0.019 inch in thickness. Active area is 0.080 by 0.180 inch. Axial field device (cylindrical) is 0.195 inch in diameter and 3/16 inch in total length.

ively shifted to bring each significant word to the index position.

When all the titles have been permuted, the computer reshuffles them and produces, on magnetic tape, an index in which all the titles are listed alphabetically according to the key word. This tape is fed to a high-speed printer which prints out the titles, in English, at a speed of 600 lines per minute.

The output tape from any index can be saved and combined with subsequent tapes to produce a cumulative index. The computer can also be instructed to produce an alphabetical author index, a bibliographical list of all the indexed documents, and other indexes according to date, language, project, or other classifications.

Design Multiple Diodes for Computers

DEVELOPMENT of a multiple germanium switching diode by Radio Corporation of America is expected to simplify the assembly of computers. The multiple diodes consist of two or three semiconductor diodes of advanced technology, packaged as single, integrated units. The multiple diode assemblies will

ANTTI RAIHA, CHIEF ENGINEER, BURGMASTER CORP. SAYS:

"Hydraulic and tape controlled turret drills need sensitive, reliable power systems..."

". . . in order to control tool penetration and table positioning where location tolerances must be held to .001-inch. We've worked with Vickers hydraulic power systems since 1951, beginning with our automatic hydraulic models, we are increasing our activity in this area as the demand for turret drilling machines and tape controlled machines grows.

"In addition to the machine shown, we use Vickers hydraulics on seven different standard models as well as on many specially designed variations of these standard machines. We rely on Vickers hydraulic power systems, not only for their unusually high quality, but because they are easy to maintain and we have the additional assurance of the availability of their worldwide service organization.

"Because Vickers application engineers have given us close cooperation and have a thorough understanding of our requirements, we've been able to develop systems that provide long, trouble-free life."

Whether you are building standard or special purpose machinery, your power and control requirements can be met precisely and economically by the proper application of hydraulic systems. Typical Vickers components and systems used by Burgmaster are shown on the facing page. They are part of the broadest line of top quality hydraulics available anywhere.

VICKERS®

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
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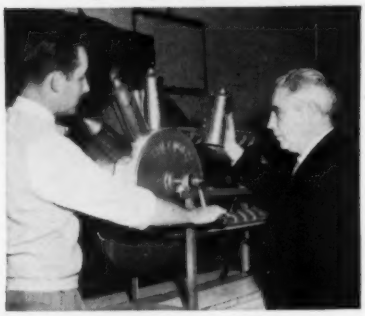
Circle 673 on Page 117

ERIEZ *Magnetic Minute*

60 seconds that will help you improve operating efficiency.



Let Eriez experience and know how be your MAGNETIC ENGINEERING DEPARTMENT

Eriez offers you a wide choice of magnetic engineering services at your plant . . . services which are the result of our research, field testing, and product development programs.

A wealth of magnetic know-how is available from our full staff of engineers and research and development personnel continually working on new ideas, new designs, new products, new applications.

Eriez devotes a major share of its engineering time to solving customers' problems in 3 major fields:

1. Use of Permanent Magnets to solve problems of separation of tramp iron or fine ferrous contamination.
2. Magnamation® — the principles of permanent magnetism applied to automation, particularly pertaining to ferrous parts, cans, etc.
3. Vibration — both electro-permanent vibratory feeding of all types of bulk materials and in bin vibration.

Whether you're an equipment manufacturer or a direct user, our wealth of technical help is available to you. Write to Chief Engineer:

ERIEZ MANUFACTURING CO.
119 WA MAGNET DR., ERIE, PA.
ERIEZ OF CANADA LTD.
P. O. BOX 5, STA. W—TORONTO, ONT.

MAGNA-THOUGHT

Engineering field service is one of our prime assets. Eriez men in the field are always ready with the information, help, and counsel you may need.

C. B. Giermak

CHESTER GIERMAK
Sales Manager

ERIEZ

A GROWTH COMPANY . . .
10 NEW PRODUCTS IN THE LAST 5 YEARS

Circle 674 on Page 117

simplify the job of building a logic network. This should permit quicker assembly schedules, greater space savings, and lower production costs. The diodes are manufactured by a process which provides high switching speeds as well as mechanical and electrical stability.

AIR GAGING equipment has been added to Radio Corporation of America's line of precision inspection and measuring systems. Because of their modular design, units may be used individually or grouped together for multiple gaging operations. They are designed for bench-type operations and for integration into automatic systems. The air flow principle of the equipment provides a fast and accurate means of making dimensional and functional checks on precision parts.

Navy Automates Issue of Stock

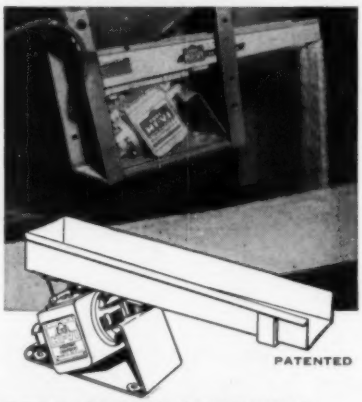
CONTRACT to produce and install an automatic handling system has been awarded by U. S. Navy to Alvey-Ferguson Co. Installation of the system will be at the Naval Supply Center, Oakland, Calif. The system, involving 23,000 ft of conveyors and a contract for $1,702,998, applies a Navy concept in warehouse mechanization. Through the use of conveyors, diverters, sort-

---

SELECTIVE TEST maintenance panel to reduce time for maintenance checks by 50 per cent or more is included on DynaPath-20 numerical control systems made by Bendix Corp. The panel provides the means to isolate and test specific logic areas and functions. Checks are made by progressively isolating each logic area and measuring its marginal operating level. By isolating each function before continuing to the next, any malfunction can be located immediately.

ERIEZ *Magnetic Minute*

60 seconds that will help you improve operating efficiency.



FEED MOST ANYTHING, FROM OUNCES TO MANY TONS PER HOUR

There's an Eriez Vibratory Feeder to handle anything from powders to parts, rivets to rocks!

Versatile, AC operated Hi-Vi® Feeders, with 100% range of control, provide accurate, economical performance whether you're feeding a few ounces or many tons per hour. They're ideal for many feeding operations including spreading, sorting, aerating, cooling, drying, sifting, separating, proportioning, formulating, mixing, coating, and dusting.

Only Eriez gives you this exclusive combination of advantages: No rectifier needed (AC operation) . . . Totally enclosed drive element is ideal for hazardous, dusty, wet, or corrosive conditions . . . New fibre glass springs assure superior performance and control, longer life because spring breakage is practically eliminated.

Choose from many models for light, medium, or heavy duty applications.

For big new catalog, write to:

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MAGNA-THOUGHT

The selection of any piece of equipment should be based on its ability to perform effectively on the job.

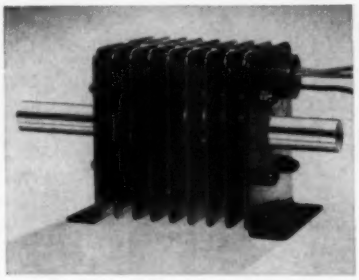
R. J. Torrey

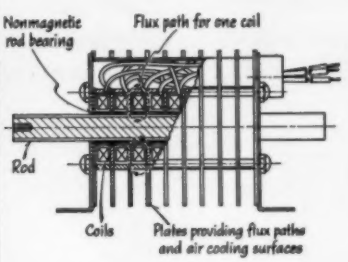
R. J. TORREY
Manager
Research & Development

ERIEZ

A GROWTH COMPANY . . .
10 NEW PRODUCTS IN THE LAST 5 YEARS

Circle 675 on Page 117





ELECTROMECHANICAL ACTUATOR designed for long stroke with accurately controlled force and response to energization has been announced by Skinner Precision Industries Inc. under the name Polynoid linear actuator. Principle of operation is that of a conventional induction motor working from either single or polyphase alternating current. Wiring of the unit's coils in proper sequence produces a traveling magnetic field which induces current in a movable rod. The rod is of uniform cross-section and acts as the motor armature. Reaction of the current with the magnetic field produces forces which cause rod motion in the direction of magnetic field travel. A shift in phase sequence of the polyphase unit or a change in shading of the single phase unit results in reversal of force and reciprocating motion.

Some of the features of the device include:

- Stroke can be any length from zero up to the stator length without external bearings and is unlimited if bearings are provided.
- Uniform output force. Plunger remains in the stator so the electrical configuration remains constant at all times.
- Uniform power requirement. Power input is constant at all positions because the electrical configuration is uniform.
- Uniform response to energization. Force is applied at energization, gives prompt uniform movement of any constant mass or load.

Actuator is built for either continuous or intermittent duty at 220 and 440 v, 3 phase, and 110 v, single phase operation. In positioning and moving applications, the intermittent duty rating allows the over-all size of the actuator to be reduced, or the output force to be increased. Forces available range from less than a pound to a practical maximum of approximately 100 pounds.

ers, and various electronic equipments, stock issues are completely automated from picking to packing. Similar systems, on a smaller scale, are in operation at the Navy's Supply Centers in Norfolk, Va. and Bayonne, N. J.

EQUIPMENT to coat electric motor armatures with epoxy plastic has been built by W. S. Rockwell Co. Powdered epoxy is applied to uniform thickness in slots and on both ends without coating the peripheral surface of the armature or the shaft. Fixtures on a chain conveyor move the parts through preheating, coating, curing, and cooling operations which are continuous and automatic.

Refinery to Use Continuous Blender

IN-LINE BLENDING system, manufactured by Fischer & Porter Co., will be installed at the Standard Oil Co. (Ohio) No. 1 Refinery in Cleveland. The $100,000 instrumentation package includes transistorized digital readout and control modules with extremely precise turbine flowmeters for continuous blending of specification gasolines. Each of 12 components or additives will be pumped from storage into a common pipeline which delivers blended gasoline directly to customer barges or to Sohio's tank farm. A memory device in the control system will precisely regulate the flow of each stream so that the percentage of each component in the total quantity delivered can be held within ±0.5 per cent.

CONTRACT of approximately $835,000 has been awarded by the U. S. Post Office to Atlantic Div., Aerojet-General Corp. for the design and installation of an advanced parcel post sorting system in the Biscayne Annex of the Miami post office. The equipment will feature a time sharing concept, permitting many parcel sorts with a single piece of equipment.

NEW

Stromberg-Carlson® lightweight telephone handsets

. . . for a wide range of applications such as dictating systems, mobile radio, carrier and microwave.

These new lightweight Stromberg-Carlson handsets, No. 33 and No. 35, incorporate push-to-talk switches, broadening the range of their applications. Both feature high-gain, high-efficiency transmitter and receiver.

The No. 33 model is furnished with a bar-type switch, located on the underside of the handle.

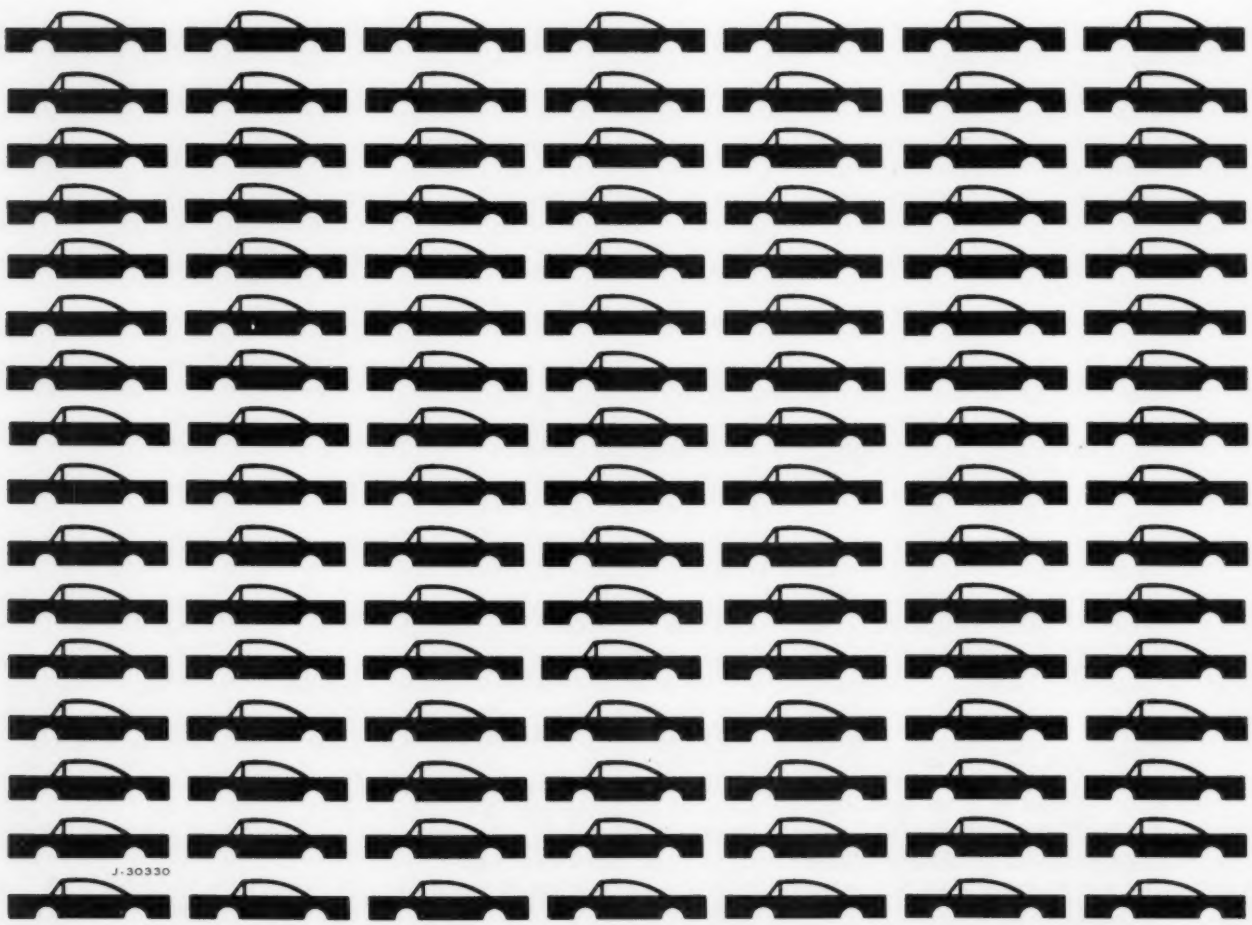
The No. 35 handset is furnished with a button switch on the side of the handle near the receiver end. Also available with both button and bar switches.

For technical details and ordering information, contact any of these sales offices: Atlanta—750 Ponce de Leon Place, N.E.; Chicago—564 W. Adams Street; Kansas City (Mo.)—2017 Grand Avenue; Rochester—1040 University Ave.; San Francisco—1805 Rollins Rd.

GENERAL DYNAMICS /ELECTRONICS

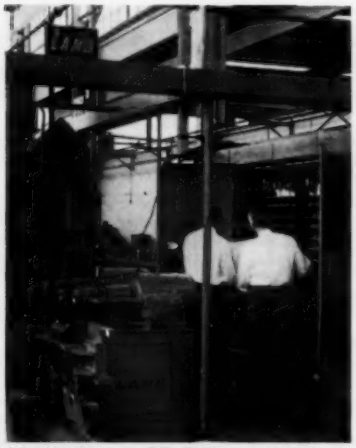
Circle 676 on Page 117

The Westinghouse BF Relay is helping the automotive industry solve its floor space problem. One automotive customer was able to reduce the length of a single control panel from 36 feet to 22 feet. Another eliminated one of three panels. The Westinghouse BF Relay is a new concept in relay design tailored to space-saving needs of automation. As many as four BF Relays fit in the space of



one old style relay. Besides being small, performance excels other machine tool relays. Learn how it can help you gain valuable floor space for more productive uses. Contact your Westinghouse sales engineer or write: Westinghouse Electric Corporation, Standard Control Division, Beaver, Pennsylvania. *You can be sure . . . if it's* **Westinghouse**

Automotive industry saving thousands of dollars in floor space with the new Westinghouse BF Relay



Westinghouse BF Relays control six transfer lines built for the automotive industry by F. Joseph Lamb Co., Detroit.

Circle 677 on Page 117

SPHERCO®
BEARINGS

If you have applications involving linkage or transfer of motion, SPHERCO Bearings can supply your needs in a wide variety of materials with a quality that will give you top performance under normal or high temperature conditions.

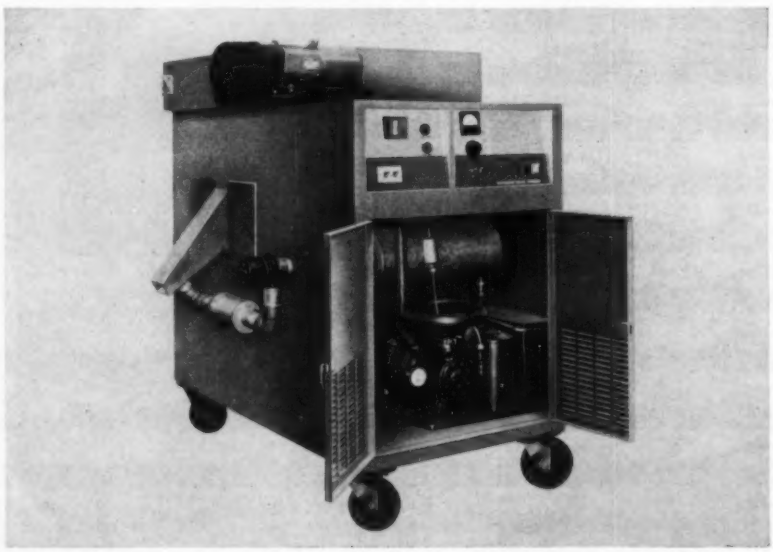
WRITE FOR BULLETIN 560

SPHERCO
A PRODUCT OF
SEALMASTER BEARING DIVISION
STEPHENS-ADAMSON MFG. CO.
22 RIDGEWAY AVE. • AURORA, ILL.

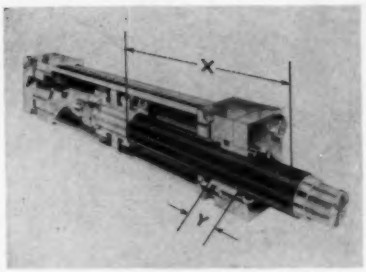
Circle 678 on Page 117

SPOTLIGHTING PEOPLE

Leo Botwin promoted to assistant chief engineer of Norden, Div., United Aircraft Corp. . . . **John W. Anderson** named vice president of engineering and **Frederick G. Miller** appointed director of operations, both in the Electronic Data Processing Div., Minneapolis-Honeywell Regulator Co. . . . **Edward Eugene Harriman** appointed director of the Office of Research and Engineering, Post Office Dept. . . . **Albert C. Kruse** named factory manager of Chainveyor Corp . . . . **William C. Iversen** appointed manager of manufacturing engineering for the Data Recorders Div., Consolidated Electrodynamics Corp. . . . **Benjamin F. Bennett** named manager of general industry engineering in the Industry Control Dept. at General Electric Co. . . . **H. Eugene Crow Jr.** appointed engineering manager of television systems for the Kin Tel Div., Cohu Electronics Inc. . . . **William C. Richards Jr.** of Bellows-Valvair elected president of the National Fluid Power Association. . . . **Paul N. Gustafson** appointed manager of the Cone-Drive Gears Div. and **George Mickas** named manager of the Research and Development Dept., both at Michigan Tool Co. . . . **Philip Spergel** promoted to director of engineering of the Systems Div., Epsco Inc. . . . **C. E. Walton** elected president of Pace Controls Corp. . . . **Dr. William S. Tandler,** system automation engineer and **David N. Smith,** automatic controls engineer, have joined the staff of Arthur D. Little Inc. . . . **J. V. Holdam** elected vice president of Dresser Industries Inc. . . . **Alexander J. White Jr.** appointed executive director of the National Association of Relay Manufacturers. . . . **Kenneth M. Lord** elected vice president manufacturing and purchasing of the Raytheon Co. . . . **Madden Travis Works** named chief engineer for the production of Flo-Ball valves at Hydromatics Inc. . . . **Chester W. Nimitz Jr.** elected vice president of the Perkin-Elmer Corp. and general manager of its Instrument Div. . . . **R. K. Turner** elected vice president of Union Carbide Corp. and **William B. Humes** appointed president of Union Carbide Plastics Co., a division of the corporation. . . . **Alexander H. Reynolds Jr.** elected vice president and **Stephen Loidl Jr.** named treasurer and controller, both at Leeds &



CLEANING MACHINE moves parts automatically through a series of rotating wheels where they are immersed in ultrasonically agitated Freon, rinsed, drained, and discharged clean and dry. Vapor loss is minimized by a closed circuit recirculating air system. As parts pass through wash, rinse, and dry cycles, solvent-laden air is drawn up through chilled coils and the Freon condensed out for return to the rinse sump. The recirculating air is reheated and reintroduced at the parts discharge end, passing counter to parts movement and extracting traces of solvent from the parts. Because of its fast cleaning action and design features, the machine built by AutoSonics Inc. can be integrated in lines with parts fabricating equipment.



BRONZE bearing material is put on the shaft, *x*, and the bushing, *y*, is hardened steel in this illustration of a design for reciprocating piston or guide rods. Thomson Industries Inc. has developed the bronze coated rod material for use in such applications. Bearing bronze is fused on the surface of a steel rod by a high temperature spraying operation. The rod is subsequently ground and straightened. Not only is the area of wearing material increased over conventional designs, but the controlled porosity of the coating gives good lubricant retention.

Northrup Co. . . . **Horace S. Daley** appointed manager of the Numerical Control Dept. at Diehl Mfg. Co. . . . **Siegfried Nuber** named supervisor of research and development at Warner Electric Brake & Clutch Co. . . . **Sid W. Farley** appointed manufacturing manager of Sparton Electronics, Div., Sparton Corp. . . . **Carey Carpenter** elected executive vice president of Copolymer Corp. . . . **John Leo Scarry** named assistant general superintendent, primary production of the Riverdale plant of Acme Steel Co. . . . **Harold E. Felix** appointed vice president and director of engineering at Midwestern Instruments Inc. . . . **Charles S. Mertler** named engineering vice president of Stevens Mfg. Co. Inc. . . . **Rigdon Currie** and **Sanford M. Roberts** have joined Bonner & Moore Engineering Associates to help organize a process analysis and control activity.

SPOTLIGHTING PLANTS

Crown Zellerbach Corp. has begun an $8.2 million modernization program in its Bogalusa, La., pulp and paper mill. A new all-purpose paper machine to be installed, is designed to produce a 120-inch trim sheet, with a daily capacity of from 95 to 100 tons. . . . **Westinghouse Electric Corp.** has formed a new industry systems department with responsibility for the conception, de-

"Big Fellow" BELLOWS

Custom-Made by Robertshaw... up to 6 Ft. in Diameter

In nose cones, missiles, industrial applications, you can now specify the strength and flexibility of metal bellows in sizes up to six feet in diameter . . . and in any desired length. *You* specify . . . *we'll* deliver!

Custom-made in single, 2-ply or 3-ply thickness — with each ply up to .060" in thickness — these new Big-Fellow bellows broaden your design scope to make possible new concepts in large-size flexible connections under extreme conditions of heat, cold or pressure.

These huge bellows can be supplied in monel, brass, bronze, stainless steel, inconel or other materials, depending on properties and characteristics desired for your particular purpose.

How about smallness?

Our size range is equally complete in that direction, too . . . with bellows down to ¼" in diameter.

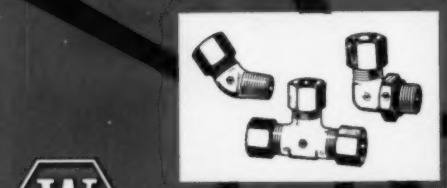
Free catalog with essential information on bellows design and characteristics. Ask for Catalog RK-R.

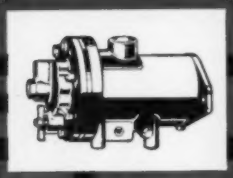
Robertshaw

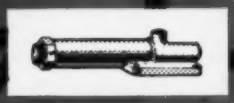
MR CONTROLS

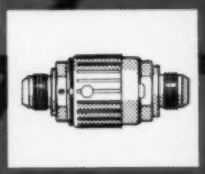
Robertshaw-Fulton Controls Company

FULTON SYLPHON DIVISION • KNOXVILLE 1, TENNESSEE









WEATHERHEAD ERMETO

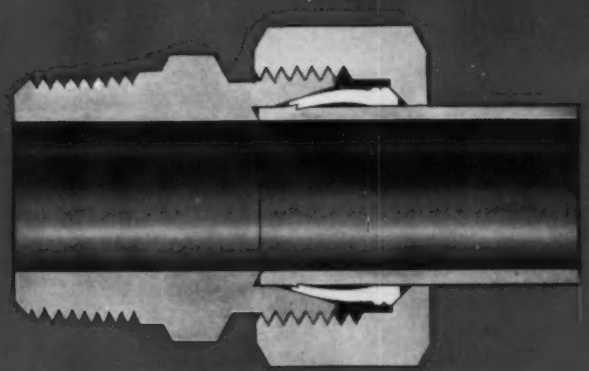
"THE ONLY FITTING WE'VE FOUND THAT ELIMINATES TROUBLE"

This is typical of reports from users of these self-sealing, high-pressure flareless connectors. Reasons: ease of assembly and disassembly; no special tooling required; avoids threading and flaring while providing positive seal; reusable—maintaining no-leak, stress-free support of tubing after multiple make and breaks.

Weatherhead Ermeto fittings are engineered to withstand severe vibration, shock, pulsating loads, temperature extremes, and pressures to 15,000 psi.

For your fluid system reliability, specify Weatherhead Ermeto.

A complete range from ⅛" to 2" is available from your nearby Weatherhead distributor.



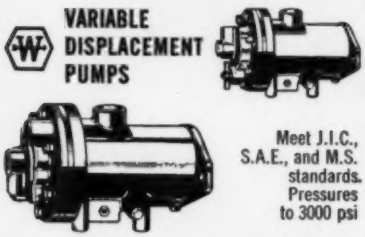
ERMETO®
"Hermetically sealed"

THE WEATHERHEAD COMPANY
CLEVELAND 8, OHIO

Circle 680 on Page 117

HYDRAULIC POWER
Components

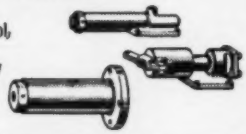
VARIABLE DISPLACEMENT PUMPS



Meet J.I.C., S.A.E., and M.S. standards. Pressures to 3000 psi

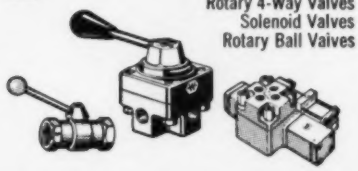
PUMP CONTROLS

Pressure Control, Automatic (Constant) Flow Control, Manual Displacement Control



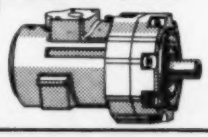
DIRECTIONAL CONTROLS

Rotary 4-Way Valves
Solenoid Valves
Rotary Ball Valves



HYDRAULIC DRIVES

Fixed Displacement Hydraulic Motors, Reversible Variable Displacement Hydraulic Motors (Integrated Torque and Speed Control)



HIGH PRESSURE HOSE AND FITTINGS

Swaged, Crimped, and Field-Attachable Flexible Hose Ends.
Flared and Flareless Tube (Pipe) Fittings.
Integral Check Valves

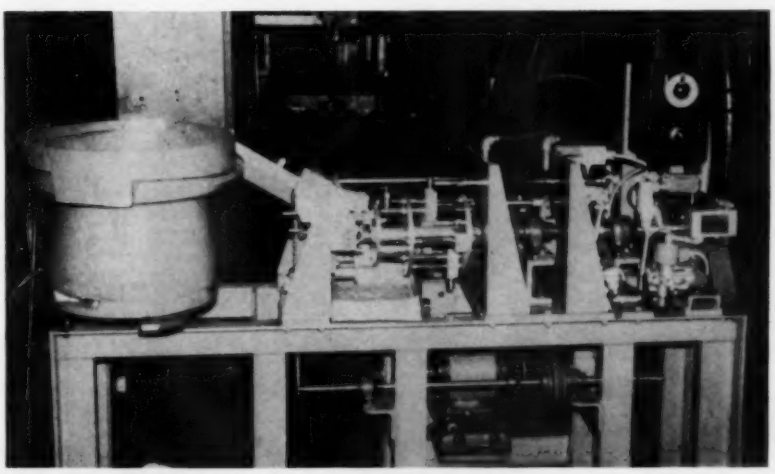
SELF-SEALING COUPLINGS

Ball Check Valve Type
Full-Flow Rotary Ball Type

THE WEATHERHEAD CO.
300 EAST 131 ST. • CLEVELAND 8, OHIO
Distributors in all major markets

Circle 681 on Page 117

plex systems for control of processes in industry. . . . **Textile Machine Works** has purchased J. L. Ferguson Co. and it will be known as the Packomatic Division. Operations of the new division have been transferred from Joliet, Ill., to Reading, Pa. . . . **Olin Mathieson Chemical Corp.** has started a multi-million dollar expansion program at its Omal, Ohio, aluminum rolling mill. The new facilities to be added include a 66-inch cold-rolling mill, a 36,000 sq ft building to house the mill, and an addition to the hot strip mill. . . . **Benerson Corp.** has formed a separate division to continue the firm's work in the design, development, and production of automated assembly equipment. Name of the new unit is Benematic Division. . . . **Laboratory for Electronics Inc.** and **Tracerlab Inc.** have agreed to merge the two companies. Plans are being made to enter a formal agreement of combination which will be submitted for stockholder approval. LFE will be the surviving company. . . . **Fenwal Inc.** has begun construction on a new plant for office and production use adjacent to their research laboratory in Ashland, Mass. The plant will occupy 106,000 sq ft of space and will be expandable in two horizontal directions. . . . **Robertshaw-Fulton Controls Co.** has purchased the Lux Clock Mfg. the Lux Time Division under present Lux management. . . . **S-P Mfg. Corp.** has signed a licensing agreement covering the manufacture and sale of S-P products by the Compagnie Parisienne d'Outillage a Air Compagnie of Paris, France. Equipment involved in the agreement includes non-rotating cylinders, boosters, and air/oil tanks. . . . **Hunt Electronics Co.** is the name of a newly formed electronics firm located in Dallas, Tex. The firm will manufacture high-voltage, high-current silicon controlled rectifiers. . . .**General Electric Co.** has begun construction on a new 39,000 sq ft computer laboratory at Sunnyvale, Calif. The $1.5 million development will be devoted to advanced computer technology in industrial and commercial areas. . . . **Brooks Instrument Co. Inc.** has acquired Francisco Engineering Co. and will operate it as a separate entity under the name of Hydropoise Inc. Headquarters and plant have been moved to Scottsdale, Ariz. The subsidiary will manufacture electronic digital transmission and computer control equipment. . . . **Norton Co., Abrasive Division** has established a new department which will be responsible for developing new products. One of the projects is the development of further information on the subject of abrasive machining. . . . **Hydraulic Research**

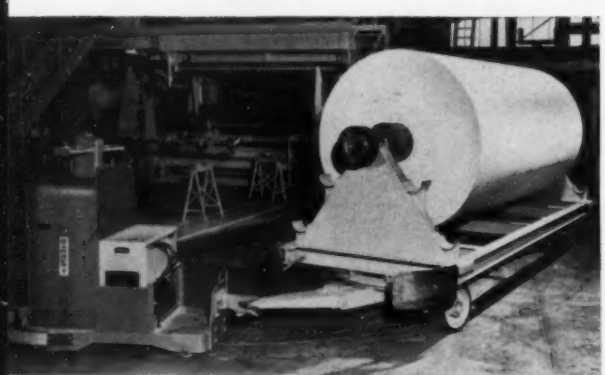


TUBULAR CAPACITOR painting machine simultaneously paints ceramic capacitor tubing both inside and outside. Adjustment on the machine allows painting any diameter from 0.121 to 0.312 inch OD and lengths from 1/16 to 1⅞ inch. Outside of the tube can be painted from end to end or in any desired parallel bands. The inside can be painted over the entire depth of the tube or to any length required. Machine was designed by E. Schmidt of Associated Professional Engineers and built by Triade Tool Co.

Here in Large Steam Turbine-Generator Dept. of General Electric Company, Guide-O-Matic goes to work. At central control point, dispatcher pushes buttons for control stops. Then driverless tractor moves down the aisle for loading and unloading of materials and parts. Thus, no accumulation of materials is required in the working areas; yet, workers have quick access to various items they need. This is one of many production-line applications of a Guide-O-Matic system.

costs go down wherever you

BARRETT *driverless*



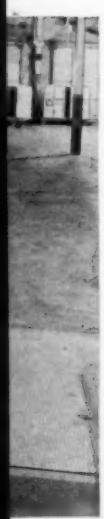
Do you have bulky materials to move? The photo on the left shows a driverless Guide-O-Matic hauling large rolls of paper, moving from warehouse to production area.

Any kind of warehousing operation may be improved with the help of a Guide-O-Matic system. This includes department store application (as illustrated at right) as well as any wholesaling operation.

Lower photo demonstrates Guide-O-Matic's versatility. This application involves a 5-mile run, in and out of doors, moving small items from multiple warehouses to shipping area.

move materials by

GUIDE-O-MATIC®



Make production operations faster and more efficient. Speed up warehousing. Add precision and accuracy to material movements. *Save money.*

These are the achievements of Barrett Guide-O-Matic systems. Applications are extremely broad—from moving heavy steam turbine parts for assembly... to distributing small supply items. Some of the driverless Guide-O-Matic uses appear on these pages. There are many, many more —and undoubtedly a potential cost-cutting use *in your plant.* Write for Guide-O-Matic "survey"—without obligation.

PLANTRONICS DIVISION
BARRETT-CRAVENS COMPANY
654 Dundee Road • Northbrook, Illinois

Barrett Handling Equipment

BARRETT

We'll be glad to arrange for a demonstration of a nearby installation, or film showing of "New Horizons in Material Handling." Write today.

Circle 682 on Page 117

GUIDE-O-MATIC *YOUR SUREST LINE OF PROGRESS*

How to use
FLUID POWER
✓ efficiently
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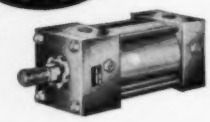
PROVEN QUALITY
SP
CYLINDERS • BOOSTERS

SERIES A



Standard Cylinders
AIR or OIL
Without Modification

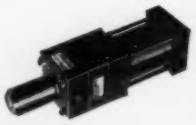
Save money with S-P's complete line; rated 200 psi air, 500 psi oil or water; 23 mounting types; 11 bore sizes—1½" thru 14"; see Catalog 110C.

SERIES B

HIGH PRESSURE
Hydraulic Cylinders

Get smoother, more precise power; ruggedly built, interchangeable; 2000 psi (3000 psi non-shock); 12 bore sizes—1⅛" thru 12"; get Catalog 117.

SERIES C



Air-Oil BOOSTERS

Save money, save space; boost 80 psi line air to 3000 psi hydraulic power with no added power consumption, no maintenance; see Catalog 116.

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A-2883A

The S-P Manufacturing Corp.
A BASSETT COMPANY
30201 Aurora Road • Cleveland 39, Ohio

Circle 683 on Page 117

and Mfg. Co. has formed a new division for the design, development, and manufacture of filters for all types of fluids.

MEETINGS AND EVENTS

Sept. 6-8—

Joint Nuclear Instrumentation Symposium. Cosponsored by IRE, AIEE, and ISA. To be held North Carolina State College, Raleigh, N. C. Additional information from IRE headquarters, 1 East 79th St., New York 21, N. Y.

Sept. 6-8—

Association for Computing Machinery. National conference and exhibit to be held Statler-Hilton Hotel, Los Angeles. Details available from Association for Computing Machinery, 14 East 69th St., New York 21, N. Y.

Sept. 11-14—

Society of Automotive Engineers. Convention and engineering display of farm, construction and industrial machinery; production; power plant; transportation and maintenance; and truck and bus activities will be known as Heavy Duty Vehicle Meeting to be held Milwaukee Auditorium, Milwaukee. Additional information available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Sept. 11-15—

Instrument Society of America. Fall instrument-automation conference and exhibit to be held in Los Angeles. Conference will be in the Biltmore Hotel and the exhibit will be in the Memorial Sports Arena in Exposition Park. Additional information from society headquarters, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

Sept. 14-15—

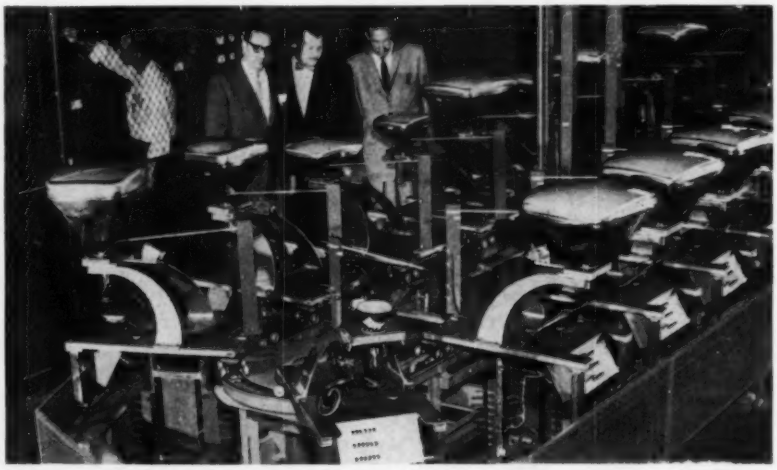
Engineering Management Conference. Cosponsored by AIEE, AIIE, ASCE, and ASME. To be held at Hotel Roosevelt, New York. More information available from AIEE, 33 West 39th St., New York 18, N. Y.

Sept. 18-20—

Standards Engineers Society. Annual meeting to be held Hotel Sherman, Chicago. More information available from society headquarters, 11 West 42nd St., New York 36, N. Y.

Sept. 20-21—

Industrial Electronics Symposium. Cosponsored by AIEE, IRE, and ISA. To be held Bradford Hotel, Boston. Additional information available from D. J. LaCerda,



CONVEYORIZED automatic tube tester can test eleven cathode ray tubes per minute. Developed by National Video Corp., the system consists of an oval-shaped track about 35 feet by six feet which accommodates 25 tube carts. Test information on each tube is recorded on tape and can be fed at command to various technical groups and processing departments. As the tubes go through the stations, the symbol OK or REJ is printed on pressure sensitive tape and affixed to the tube to indicate its status. If the tube is a reject, it carries code numbers indicating at what point or points it failed to meet the standards.

Circle 684 on Page 117→

MOTION ...*by proxy*

Motion . . . movement . . . mobility . . . call it what you will, it's the heart of industry.

Man can move parts or products by one of two basic methods: back power or finger power. Finger power means pushing a button or setting a dial, and watching the product move AUTOMATICALLY to any one of a number of predetermined points. This is called AUTOMATIC DISPATCHING.

It takes experience, research, and technical knowledge to turn out a workable AUTOMATIC DISPATCHING system; it takes Systems Engineers with electrical and mechanical experience combined with complete manufacturing and installation facilities at their disposal.

With these diversified skills and facilities, the Jervis B. Webb Company will assume complete responsibility for putting your product in motion.

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CMA

Quality metal products deserve

"the finishing touch" of Mahon

Mahon has designed, built and installed complete finishing systems for Caterpillar Tractor Corp. (makers of all types of farm equipment) and Scovill Mfg. Co. (major supplier of cosmetic containers).

fine
finishing
for any size,
any volume
product . . .

from giant tractors to small lipstick cases

No matter what your end-product may be, if your production processing requires metal-cleaning, rustproofing or any-type finishing from heavy-duty enamels to sales-stimulating lacquers, you can 'lean' on Mahon's Industrial Equipment Division. Here's an organization with the broadest finishing experience . . . and the one-source capability for planning, engineering, fabricating, erecting and servicing that means quality and efficiency at lowest true cost. Mahon designs industrial equipment but *engineers results from start to finish.* If you are interested in new or improved finishing facilities, Mahon would like to work with you in doing the job right.

MAHON INDUSTRIAL EQUIPMENT

• Complete Finishing Systems • Metal Cleaning Equipment • Pickling Equipment • Painting Facilities—spray, dip and flo-coaters • Drying and Processing Ovens • Special Process Equipment

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DETROIT 34, MICHIGAN
MANUFACTURING PLANTS—Detroit, Michigan and Torrance, California
SALES-ENGINEERING OFFICES—Detroit, New York, Chicago, San Francisco and Torrance. Representatives in all principal cities.

YOUR BIGGEST VALUE IS IN MAHON'S PLANNING AND ENGINEERING EXPERIENCE

MAHON

Circle 685 on Page 117

BUTTON STITCHING machine automatically stitches buttons to men's coats and vests at a rate over 1000 per eight-hour day. It is adaptable to either a 2-hole or 4-hole button with parallel or cross-stitching. In addition to its speed, the machine has the advantage of stitching buttons on more securely and uniformly than by hand. Unit was developed by American Machine & Foundry Co.

Badger Mfg. Co., 363 Third St., Cambridge, Mass.

Sept. 24-27—

Petroleum Mechanical Engineering Conference. To be sponsored by American Society of Mechanical Engineers at Muehlebach Hotel, Kansas City, Mo. Details available from society headquarters, 29 West 39th St., New York 18, N. Y.

Sept. 24-27—

National Power Conference. Co-sponsored by American Institute of Electrical Engineers and the American Society of Mechanical Engineers. To be held St. Francis Hotel, San Francisco. More information available from ASME headquarters, 29 West 39th St., New York 18, N. Y.

Sept. 25-28—

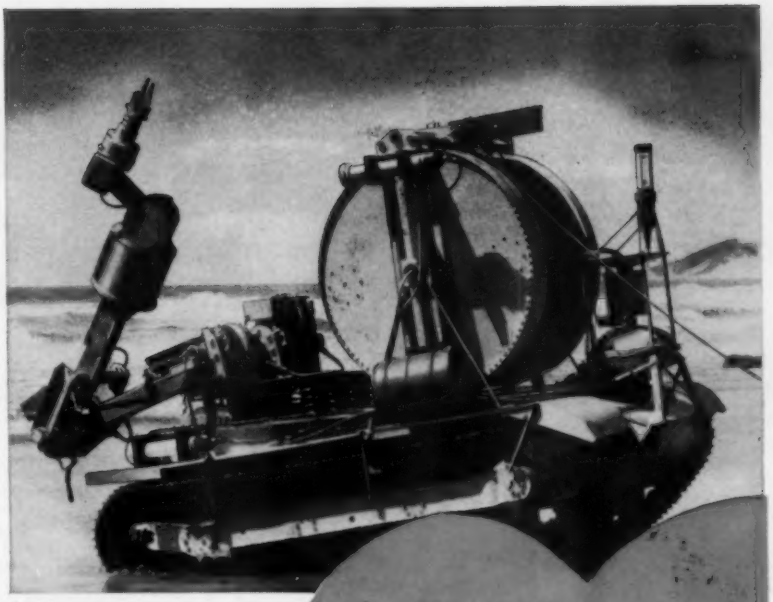
American Welding Society. National fall meeting will be held Adolphus Hotel, Dallas. Further details available from society headquarters, 33 West 39th St., New York 18, N. Y.

Sept. 25-28—

Association of Iron & Steel Engineers. Annual convention to be held Penn-Sheraton Hotel, Pittsburgh. Additional information available from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

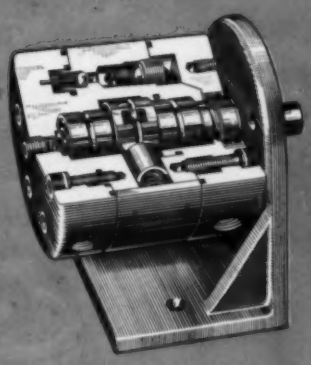
Sept. 28-29—

American Production and Inventory Control Society. National con-



REMOTE UNDERWATER MANIPULATOR BUILT FOR THE U. S. NAVY BY THE SCRIPPS INSTITUTION OF OCEANOGRAPHY OF THE UNIVERSITY OF CALIFORNIA AND THE HUDSON LABORATORIES OF COLUMBIA UNIVERSITY.

This hardy HYDRAULIC HEART operates efficiently even 20,000 ft. under water



The Heart of this Exotic Ocean Explorer Is a RACINE
MODEL D6 PUMP

A RACINE pump actuates the mechanical arm on the Remote Underwater Manipulator, a new experimental vehicle the U. S. Navy uses to explore the ocean floor down to depths of 20,000 ft. The arm makes all the motions of the human arm and hand. It picks up samples from the ocean floor . . . assembles and installs instruments in the ocean depth. Land-based remote controls operate the underwater explorer. Rated at 1,000 psi continuous pressure, the RACINE pump automatically compensates for the compressibility of oil under various sea water pressures. When you need *versatile* hydraulic components — sturdy and dependable for *any* use from research to assembly line — your best choice is RACINE!

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Circle 686 on Page 117

The Automatic Potter's Wheel first bowled over the ceramics industry in 133,345 B.C.

GREAT MACHINES OF WESTERN MAN

This backward look at the backward days of automation is lovingly dedicated to industry everywhere by Barkley and Dexter with this reminder: that industry anywhere can progress and profit from the forward looking services of B & D, one of the nation's foremost specialists in industrial mechanization and automation.

You should know more about B & D. Here is what our service consists of:

PLANNING — we determine if mechanization can help you; where it can help you; how it can help you; how much it is likely to cost; how much it will save.

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For further information, send for the folder on our services. Or better still, write us about your problem.

BARKLEY & DEXTER INCORPORATED

50 FRANKFORT STREET, FITCHBURG, MASSACHUSETTS — PIONEERS IN AUTOMATION

Circle 654 on Page 117

ference and exhibit to be held Pick-Congress Hotel, Chicago. More information available from society headquarters, 330 South Wells, Chicago, Ill.

Oct. 4-6—

Process Industries Conference. To be sponsored by American Society of Mechanical Engineers at Shamrock Hilton Hotel, Houston. Information available from society headquarters, 29 West 39th St., New York 18, N. Y.

Oct. 9-11—

International Systems Meeting. To be held by Systems and Procedures Association at Pick-Carter Hotel and Statler-Hilton Hotel, Cleveland. Details available from association office, P. O. Box 6175, Cleveland 1, Ohio.

Oct. 9-11—

National Electronics Conference and Exhibition. Cosponsored by AIEE, IRE, Illinois Institute of Technology, Northwestern University, and the University of Illinois. To be held at the International Amphitheatre, Chicago. Further details available from NEC headquarters, 228 N. LaSalle St., Chicago 1, Ill.

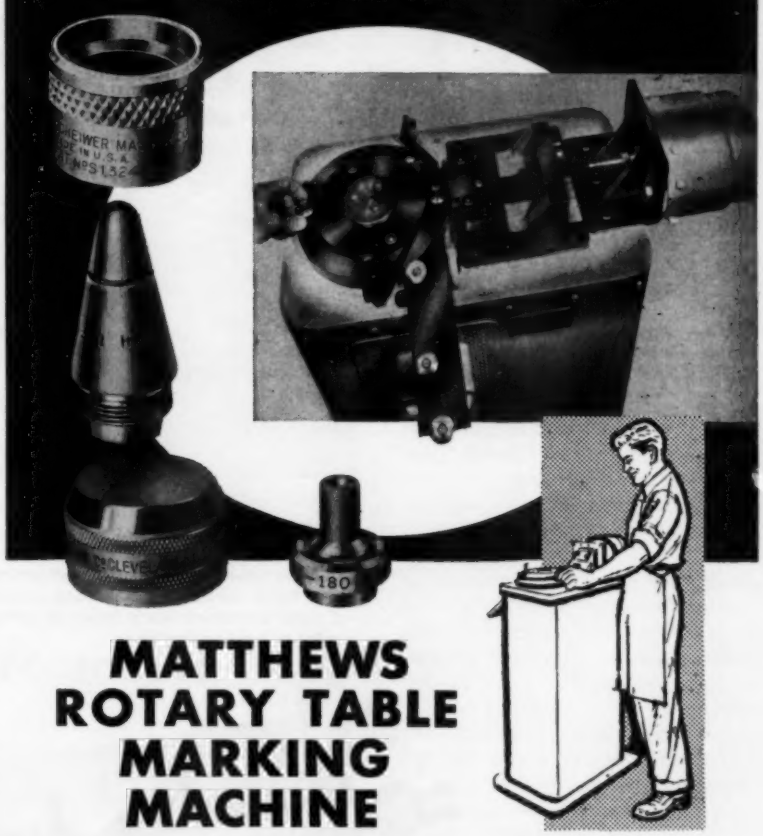
Oct. 9-13—

Aerospace Engineering and Manufacturing Meeting. Meeting and engineering display to be sponsored by Society of Automotive Engineers at Ambassador Hotel, Los Angeles. Details available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

"Well gentlemen, according to my calculations, this machine is not only degreasing, deburring, polishing, plating, and packaging your parts as previously planned, it is also eating them."

MARKS UP TO 7,000 PARTS PER HOUR

. . . Cylindrical or Cone-Shaped
. . . Solid or Tubular Design



MATTHEWS ROTARY TABLE MARKING MACHINE

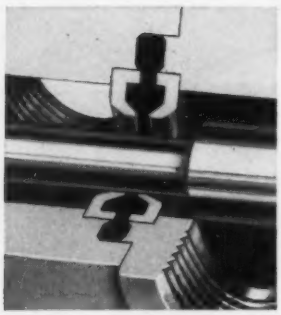
The Matthews Rotary Table Marking Machine positions, marks, and ejects parts automatically at speeds up to 7,000 per hour. Your name, trade-mark, part number or special lettering appear perfectly even on hard-to-mark, delicate and thin-walled products.

Solid marking dies may be interchanged with steel type or logo dies for variable marking . . . interchangeable machine heads are available for parts of varying size and design. Mark it with a Matthews Rotary Table Marking Machine . . . faster, clearly and more economically. Write for descriptive Bulletin 146-C9.

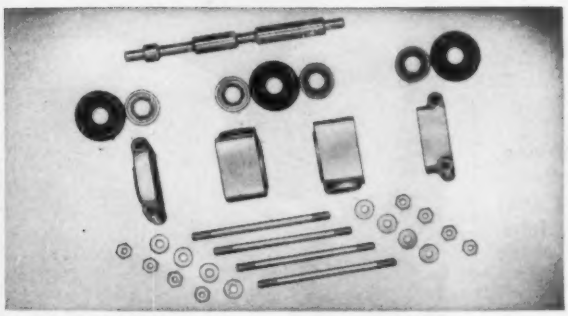
MATTHEWS MARKING PRODUCTS

JAS. H. MATTHEWS & CO.
3945 FORBES AVENUE • PITTSBURGH 13, PENNA.

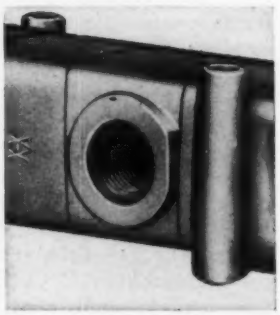
Do the air valves you buy include these quality features?



SEAL—Exclusive, triple-supported seals permit interference fit of spool for extra-tight closure with minimum wear. Usual damage to conventional "O" rings by moving spool is eliminated.



SIMPLICITY—Uncomplicated parts mean long life and easy servicing. Common parts are used extensively to simplify stocking or repair.



FLEXIBILITY—Modular Construction. Operators, mounting holes and ports may be independently rotated in 90° steps. Operator may be on either or both ends.

This high-quality "D" Pilotair® Valve is available in thousands of combinations. Tailored valves at standard model prices. Nine basic valves may have one or two of eight operators. Many types of spring return or holding functions.

if not, the chances are your maintenance costs are higher than necessary. For more information about quality Fluid Circuitry Controls for trouble-free automation, ask for Catalog A4-75.01.

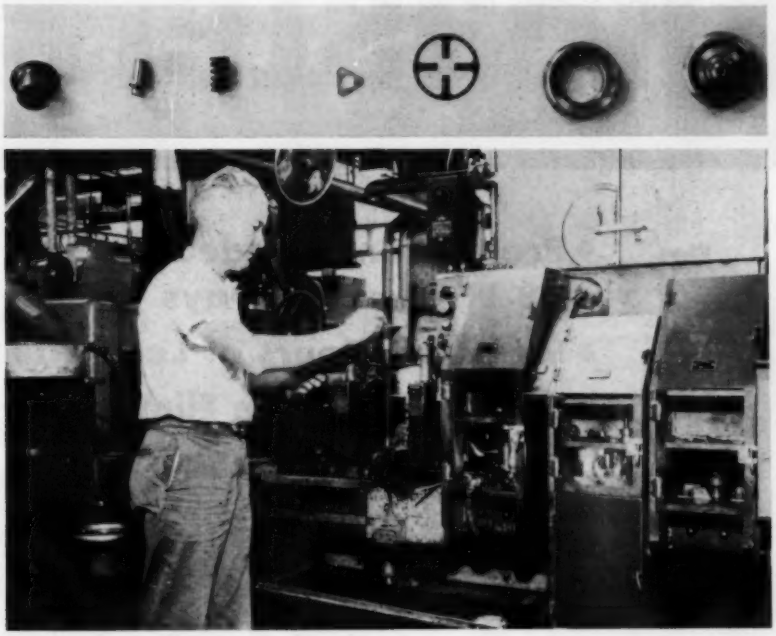
See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

Circle 656 on Page 117

By LEE D. MILLER, Associate Editor



One side of machine to assemble shock absorber check valves is visible. Machine is really two-in-one with complete setup to assemble valves on each side of machine. Fixtures do double duty by indexing through both assembly lines. The operator is hand-feeding coil springs.

Channels For Automaters

MENTION of channels to most Americans is likely to bring to mind the sources of television programs that please or plague their optical systems. Those particular channels are not often of specific interest in the building of automotive products, but there are some channels of high interest in such activities.

Some of the automotive channels are television channels too—closed circuit channels that is. One use that has been reported is to position a clam type hook over a body assembly near a body drop operation. The operator controlling the hoist is on one side of the body with a TV screen. The camera is focused on the opposite side of the body and lets the operator see when the hook is properly positioned to hoist the body.

One operator of the system has admitted that eight hours of one program can get a little monotonous at times. But he also reports that he is not subjected to any commercials on the program.

Floating Down The . . .

As the summer boating season comes to its end, some outdoor enthusiasts may also be thinking of water paths for movement from place to place.

Unfortunately, such water paths usually are not related to operations automotive. Only by tenuous logic might one see a connection with some of the dip tank operations for today's bodies, or even with the unique cars-on-water exhibit in Cobo Hall for the last SAE International Congress and Exposition.

But even if enjoyable water channels are not part of the daily scene in making automobiles, there are many interesting channels for movements from place to place. This observer was reminded of the point on a recent tour through a plant that manufactures shock absorbers.

Shock Channels

A machine used to put together check valve assemblies is a two-channel job. In essence it incorporates two progressive assembly lines on a single machine base with one set of fixtures indexing around the base to serve both sets of assembly stations. Normally both sides of the machine would be in operation, although they might be producing different modifications of the product which can be assembled in identical nests. When desired, one side of the machine can be operated alone.

Piston rod assemblies for shock absorbers are assembled on another machine. This large machine combines manual operations with automatic operations to form a practical assembly system. The machine provides a number of stations around a base with a single loop of traveling fixtures.

Operations along the main channel are improved by use of an auxiliary channel that handles an adapter used only for manufacturing purposes. The sequence of assembly operations for the piston rod unit calls for assembly of a rubber seal over a shoulder. An adapter developed to improve the assembly operation has a tapered OD. When slipped over the end of the rod and seated against the shoulder it allows easy movement of the seal past the shoulder.

Adapters are automatically placed on the ends of the piston rods as the rods are moved around the machine by the traveling fixtures. After the seals are assembled to the rods, the adapters are automatically removed from the assemblies and returned to the loading point. The return is accomplished simply by blowing the adapters through a plastic tube.

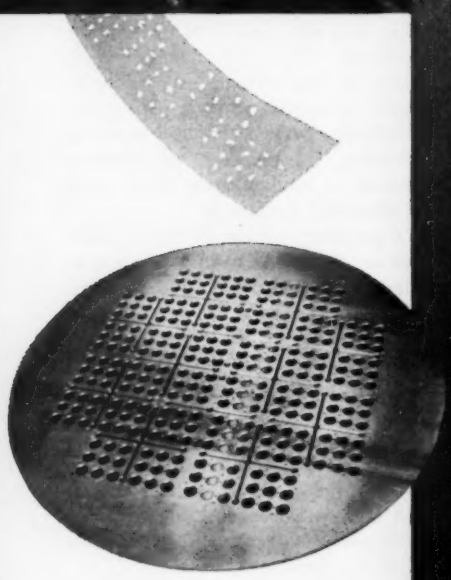
Variations

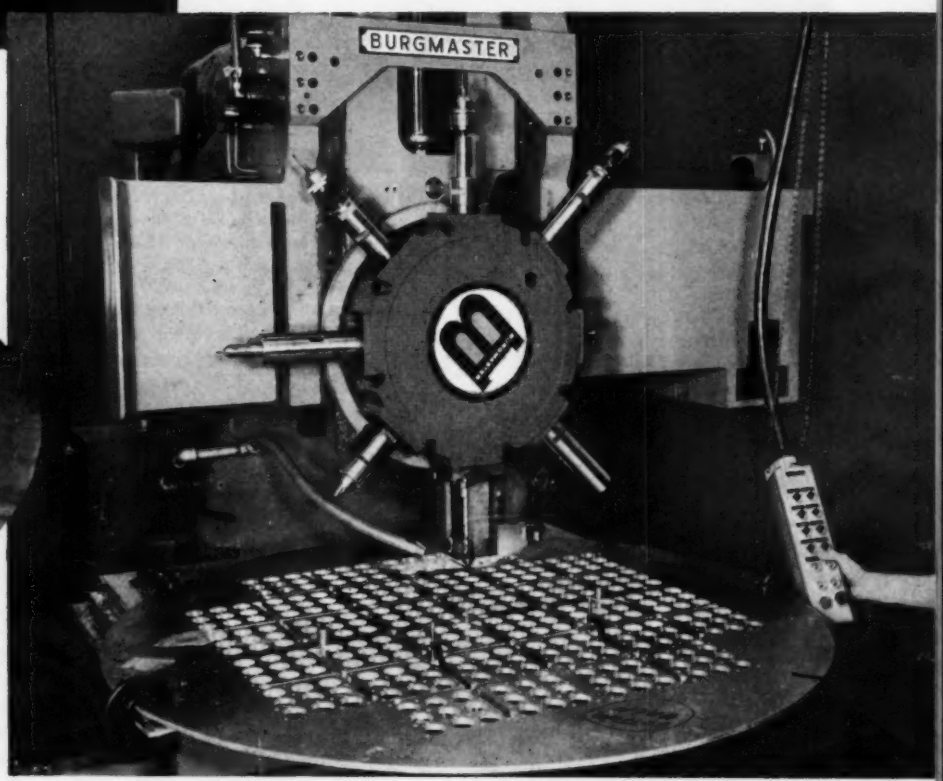
Contemplation of the flow channels in the two machines led to recollection of some other flow configurations that have been used in automatic equipment. One varia-

GENERAL ELECTRIC USES

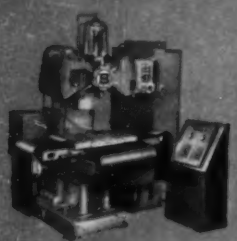
Burgmaster TAP

- **Production Speeded from 8 Weeks to 9 Days**
- **Saves 60 Hours of Lead Time**
- **$800.00 Fixture Eliminated**

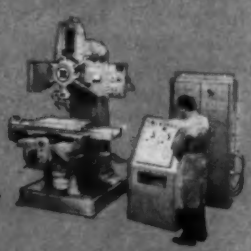




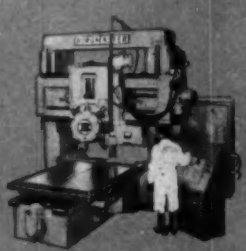
Burgmaster Model 3BHT 8-spindle, 1½" capacity in steel. Table travel 20x30, 30x45.



Model 2BHT 6 spindle, ¾" capacity in steel. Table travel 10x18, 15x26, 20x30.



Model 25AHT 6-spindle, 1¼" capacity in steel. Table travel 15x26, 20x30, 30x45.



Model 3BHT-B Double Housing Planer Type 8-spindle, 1½" capacity in steel. Table travel 48x60.

CONTROLLED TURRET DRILLS

TO PROGRAM 2,098 OPERATIONS EACH PART

(General Electric Company, Atomic Power Equipment Dept., San Jose, Calif.)

● *Tape-Controlled milling operations* are now added to the versatility of the Burgmaster Model 3BHT, 8-spindle tape-controlled Turret Drills. At General Electric's San Jose facility, 10 slots .176" wide and 3½" long, and 24 slots ⅜" wide and 10" long are milled in a 6061-TC aluminum nuclear reactor grid plate ⅜" thick. These milling cuts are rough and finish, both sides, and are all programmed in tape. 1962 additional center drill, drill, bore, ream and tap operations necessary to complete each unit are also programmed in tape and performed by the Burgmaster Model 3BHT with push-button control. All holes are held to .004" true position over entire area. In this operation, production has been speeded from 8 weeks to 9 days, 60 hours of lead time have been saved and an $800.00 fixture eliminated.

JOB FACTS

Company: General Electric, Atomic Power Equipment Department, San Jose, California.

Machine: Burgmaster Model 3BHT—"GENERAL ELECTRIC MARK II" Tape-Controlled Turret Milling, Drilling, Tapping and Boring Machine.

Part: Nuclear Reactor Grid Plate. ⅜" x 55½" diameter.

Special Attachments: Milling, Reciprocating Drilling, 3-Dimensional.

Lot Size: 2

Tolerance: .004" of True Position Over Entire Area.

Holding: 2 Pins on Sub Plate, Simple Clamps.

Machine Operations: Total 2,098 Machine Operations.
288 holes—center drill, drill, bore and ream (4)
384 holes—drill (1)
128 holes—drill and tap (2)
60 holes—drill and bore (2)
50 holes—drill (1)
10 slots—mill, rough and finish both sides (4)
24 slots—mill, rough and finish both sides (4)

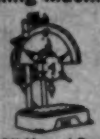
Former Method: Individual Milling and Drilling Machines with Drill Fixtures.

Present Method: All operations programmed in tape for Burgmaster Model 3BHT.

Savings: 31 Days, 60 hours lead time, $800.00 fixture.

Other Advantages: Greater Accuracy, Less Cost. No Scrap Loss, Eliminates Operator Fatigue.

World's Largest Builder of Turret Drilling Machines


"O" Manual Power Index ¼" Capacity

1C Manual Power Index ⅜" Capacity

2B Manual Power Index ¾" Capacity

2BR Ram Type Radial Drill ¾" Capacity

2BH Automatic Hydraulic ¾" Capacity

3BH Automatic Hydraulic 1½" Capacity

25AH Automatic Tape Controlled 1¼" Capacity

2BHT-3BHT Automatic Tape Controlled ¾" and 1½" Capacity

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Send for Literature

Write for bulletin describing Burgmaster 6 and 8 Spindle Tape Controlled Turret Drilling, Tapping and Boring Machines. Forty minute 16 mm sound film showing all Burgmaster Turret Drills in operation is available without charge from any office.

tion in a drilling and deburring unit handled parts for three identical stations along a straight track. Parts were received one at a time at the feed end and were to be machined at any one, but only one, of the three machining stations.

The cylinder that advanced the parts could provide two different stroke lengths—length of one part and length of three parts. Parts were moved into machining position by a three-space stroke. While the machining heads cycled, the indexing cylinder provided two one-space strokes to load parts at the feed end. When a third part was received and the heads had retracted, the cylinder produced a three-space stroke to index unmachined parts into position at the machining stations.

A system for lock assembly on a rotary index table used a unique arrangement to allow performance of a manual operation, several automatic operations, then another manual operation by the same operator, and additional automatic operations. To obtain this sequence of operations each fixture moved past the operator twice in every cycle.

Twenty-seven fixtures were mounted on the table. Each index motion covered 26 degrees and 40 minutes. Twenty-seven indexes, providing two revolutions of the table, were required to return a fixture to any given starting position. Since each position reached in the two-revolution cycle was at a different location, there was no requirement for selective cycling of tools at the individual stations.

Unlimited

On jobs where alternate tools have been selectively cycled and/or multiple fixtures provided, the parts flows have come in as many varieties as soup for lunch. The selective cycling idea has been applied, for one example, to transfer press operations so that two part configurations could be produced in a single press run. On one such job two stampings were produced by four dies. Two dies were used on all parts; the third die was used exclusively on one part configuration; and the fourth die was used only on the other part configuration. The press slide carrying the third and fourth dies was only cycled on alternate cycles of the slide carrying the two dies that operated on all parts. All work-pieces were advanced one station for each stroke of the every-cycle slide.

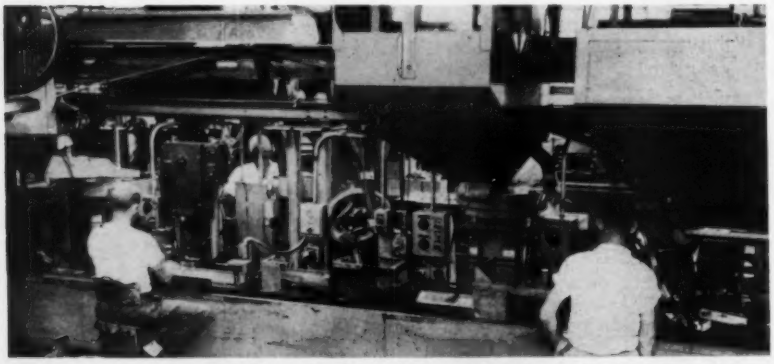
Multiple nests, at each station of a dial or linear index arrangement, have frequently been used in assembly operations. Such designs may, for instance, allow the building of two or more partial assemblies and then their final assembly into a single unit all on one machine.

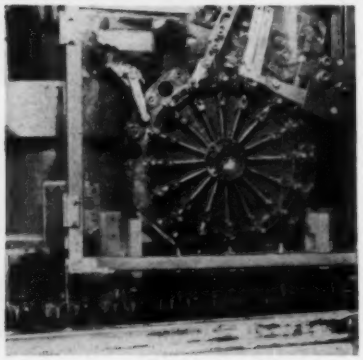
At the Fifth Conference on Manufacturing Automation, one of the operating examples discussed was an assembly machine that used a two-channel approach. Parts were placed on two different types of arbors to build up assemblies that were combined at a later station.

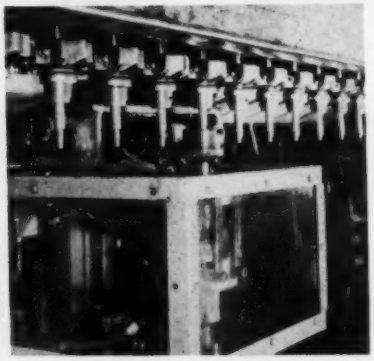
For good measure, each traveling fixture carried two *A* arbors and two *B* arbors. With duplicate tooling a station performed simultaneous operations on both *A* arbors or both *B* arbors—or even operations involving all four arbors on a fixture. How the assemblies did pour out of that machine.

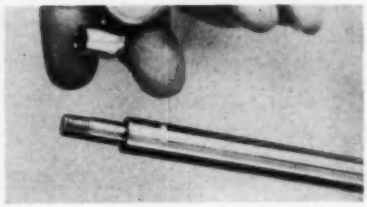
Hardening of the Channels

It may be appropriate to note that not all channels are desirable. Some mental ones appear to become suspiciously similar to ruts that are self-defeating. If channels in your operations have assumed such an appearance you may want to turn over a new leaf. In fact, you are invited to do that now by turning the leaves of this and future editions of AUTOMATION. Presenting ideas to help you develop new channels are our raison d'etre.



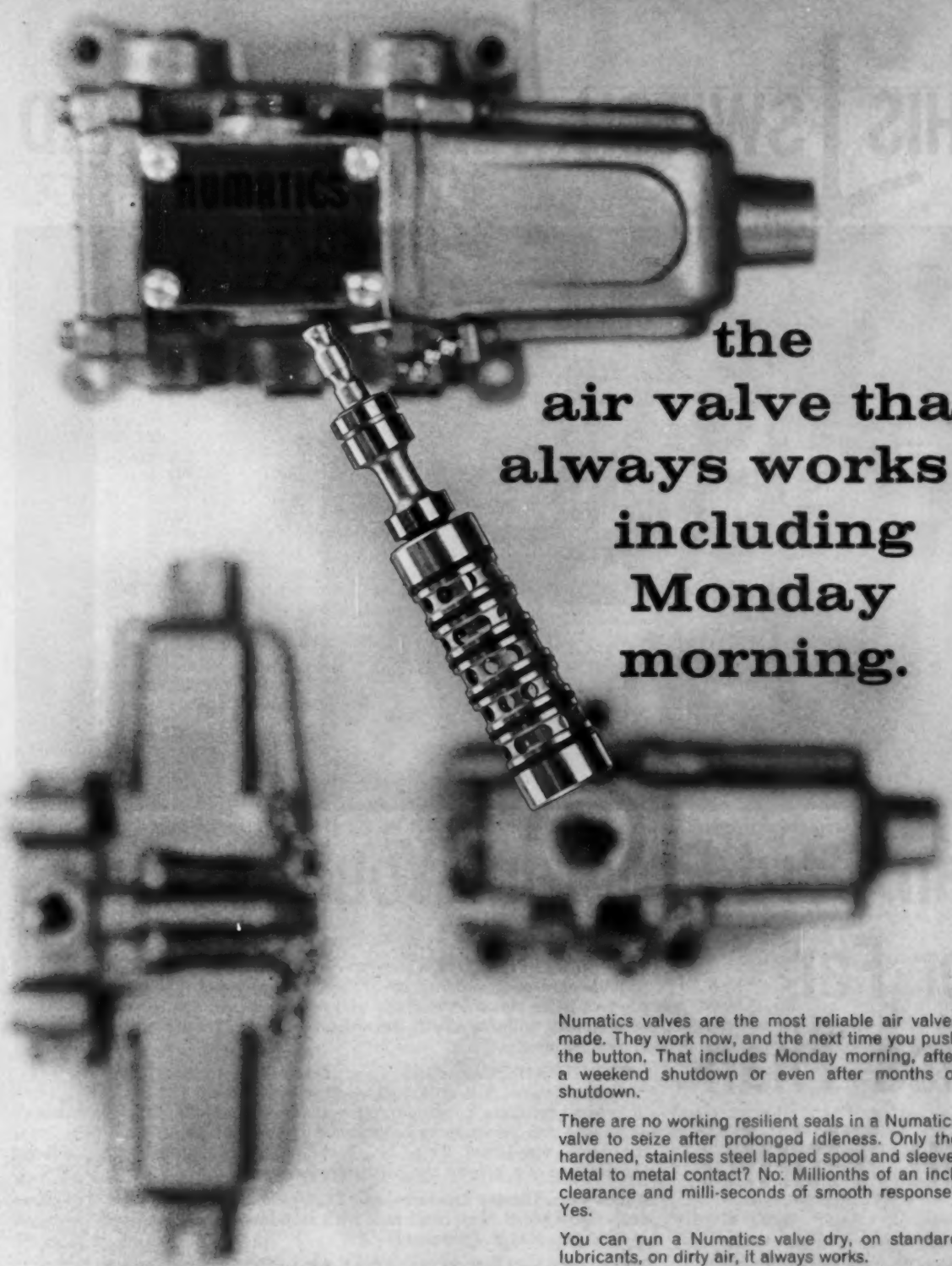






General view shows portion of a large machine that assembles piston rod components for shock absorbers. An interesting feature of the machine is a provision to automatically place and remove a manufacturing adapter (closeup above) that eases a seal over a shoulder on the rod. Ferris wheel (lower left) automatically places the adapters; removal device (lower right) lifts them off for pneumatic return to placing station.

Circle 658 on Page 117→



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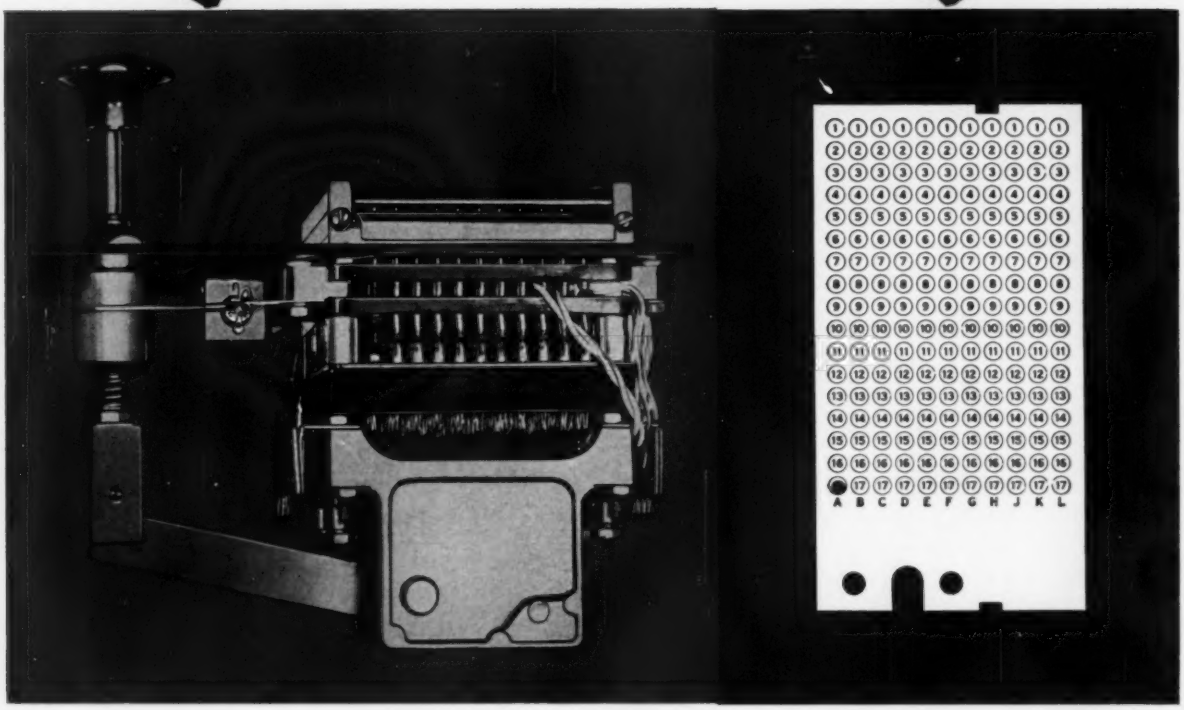

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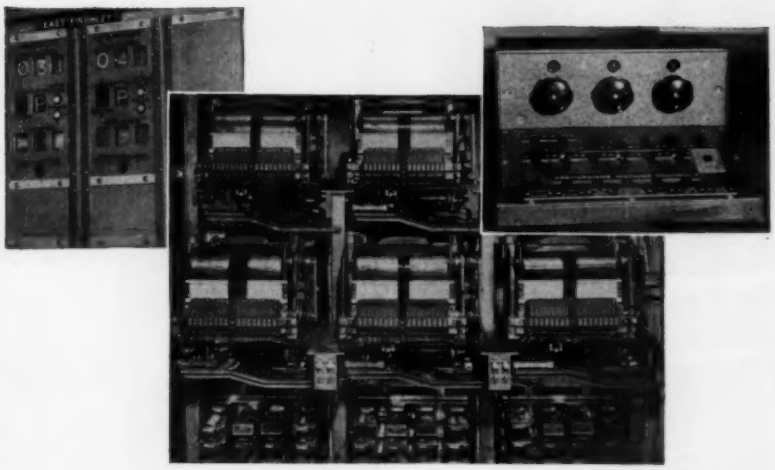


System for automatically routing trains over junctions in Northern Line of London Transport includes banks of program machines that convert coded timetable information into electrical impulses. Panels in central supervision room (left inset) show the states of program machines at remote East Finchley junction. Numbers in top rows identify trains being handled by system. Illuminated letter "P" on panels signifies that operations are under program control. Desk unit (right inset) can be connected to control the remote program machines. Numbers set on dial permit canceling trains.

Underground Operation

CONTROL of the 900 trains per day that move on the Northern Line of the London Transport underground railway system is a complex operation requiring an extensive signaling arrangement.

For straight sections of the line, safe operations are easily ensured through use of simple relay circuits that automatically signal danger when a train is approaching a section of track already occupied by a preceding train. Such circuits have been known and used for more than 50 years.

At junctions, however, it has been necessary to employ a signalman to manually control the routings of trains approaching each junction. Normal variables include destinations, sequence, and time of arrival of trains at the particular junction. Exceptions are occasioned by departures from preset schedules, trains out of order, extra trains, and canceled trains.

Responsibility for improving signaling operations of the London Transport falls within the jurisdiction of the Signal Engineer's Dept. Under the direction of R. Dell, signal engineer, this department has developed an automatic system for routing trains through junctions as well as on straight track sections of the line. The system meets requirements laid down by C. E. Dunton, chief civil engineer of the London Transport, and is being implemented continually.

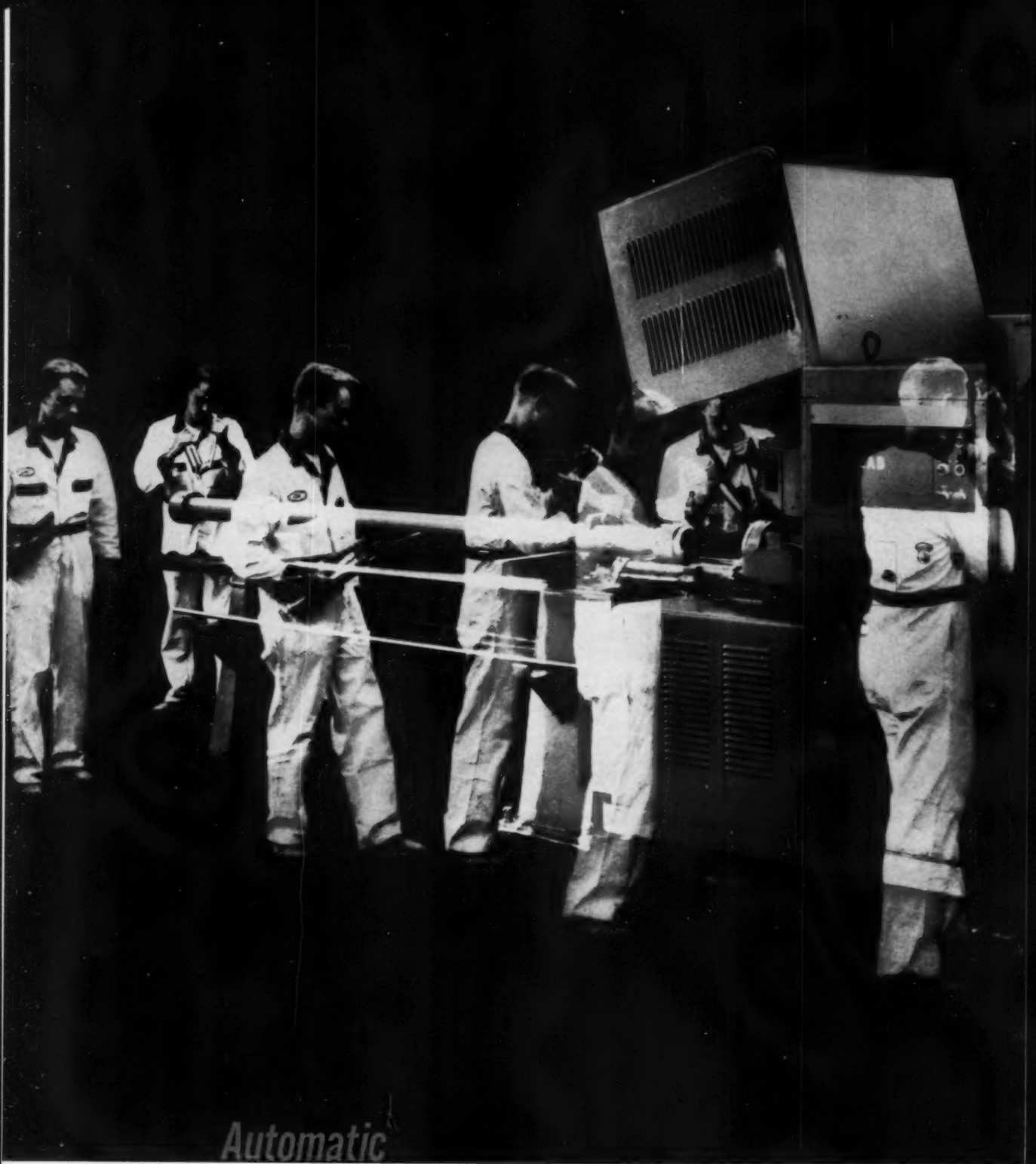
With the automatic signaling system, a train approaching a given junction is identified by a train describer system. A train arriving on schedule can be routed automatically through the junction in accordance with a preset timetable. In the event of a departure from the timetable, the train can be handled automatically by destination or time of arrival, or manually.

Heart of the control system is a program machine capable of storing and presenting timetable information about each train to be worked over a particular junction. The machine contains a plastic roll on which is typed information about each train to pass over the junction. Details recorded include train number, destination, route, and time due. Below each line of typing is a row of holes carrying the information in decimal binary form. The holes can be sensed by electric contact probes which control the signaling equipment.

For each junction a program machine is used for sequence control. The contact probes "read" the first train scheduled to approach the junction and this information is compared with information from the train describer system. If coincidence is found, the train is automatically routed through the junction. When that train has passed, the program roll indexes forward one step and the contact probes sense the next row of holes. The program roll is rewound automatically in readiness for the commencement of traffic the next morning. When the schedule changes, as for weekend operations, a new roll is inserted in the machine.

As an additional check, time control is effected by another program machine. Its roll is advanced by a master clock. Information from this machine, which is stepped by the passage of time, is compared with information from the other program machine which is stepped by the passage of trains. If coincidence is not found, a warning is sounded.

Program information from several junctions is presented at a cen-



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automatic lubrication is the key to lower costs/longer parts life/higher production

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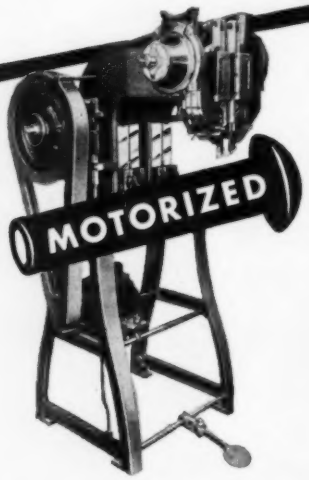
Circle 660 on Page 117

Why *Chicago Rivet* Offers TWO METHODS for Clinching Semi-Tubular Rivets

It is part of a widening service based upon industry's recognition that an assembly held together by semi-tubular rivets has great inherent strength and is usually lowest in production cost.



The Chicago Rivet MOTORIZED AUTOMATIC RIVET SETTER produces a sharp, solid blow that immediately upsets the tubular section. This method is used on 95% of all applications involving metals or non-fragile materials.

The Chicago Rivet AIRPOWERED RIVETER produces a cushioned, shock-free clinch on a tubular rivet, permitting riveting of fragile and uneven materials. This method has greatly widened the use of semi-tubular rivets.

FOR YOUR FILES

RIVET CATALOG describes 1388 standard tubular and split rivets and 25 single and multiple motorized automatic rivet setters.

AIR-POWERED RIVETING catalog contains description and specifications of 8 single and multiple riveters—also rivet setters designed for automated operation.

Why not let Chicago Rivet Fastening Engineers tell you which system is best for you. No obligation.

MOTORIZED

Line includes automatic single, multiple and automated setters.

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Line includes automatic single, multiple and automated setters.

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tral supervision room. The room also contains a graphic diagram of the areas being worked, a set of pushbuttons, and switches for the program machines.

Operations that can be controlled from the central supervision room include:

- Normal program machine working, where trains are routed automatically according to the timetable.
- In the event of a departure from the timetable, the system can continue to work automatically but trains entering a splitting junction will be signaled in accordance with their destinations and trains entering a converging junction will be signaled in order of arrival.
- All automatic working can be switched out and the routes operated manually by means of the pushbuttons.

The photographs illustrate panel indicators and a desk control unit recently added to the central supervision room at Leicester Square for automatic control of the East Finchley junction of the line. Also illustrated are several program machines used for sequence and time control.

Tokyo, Japan

One of Japan's largest manufacturers of machine tools, Tsugami Mfg. Co. Ltd., has retained the Los Angeles marketing and management consulting firm of Ward J. Jennsen Inc. to study the American market for Japanese machine tools. Objective of the nationwide research study, which will require approximately four months to complete, is to determine the extent and nature of the potential U. S. market for Japanese imports of heavy production machinery.

Dneipropetrovsk, Ukraine

One of the largest and most highly mechanized tire factories in Europe will shortly go into production at this Russian industrial center, according to the British publication *Automation Progress*. The plant has been supplied by a consortium of British companies operating under the name of Rustyfa Ltd. Consultants to the consortium were Dunlop Advisory Services Ltd.; mechanical handling equipment was planned and supplied by Geo. W. King Ltd. Capacity of the plant will be 2 million tires per year.

Circle 661 on Page 117

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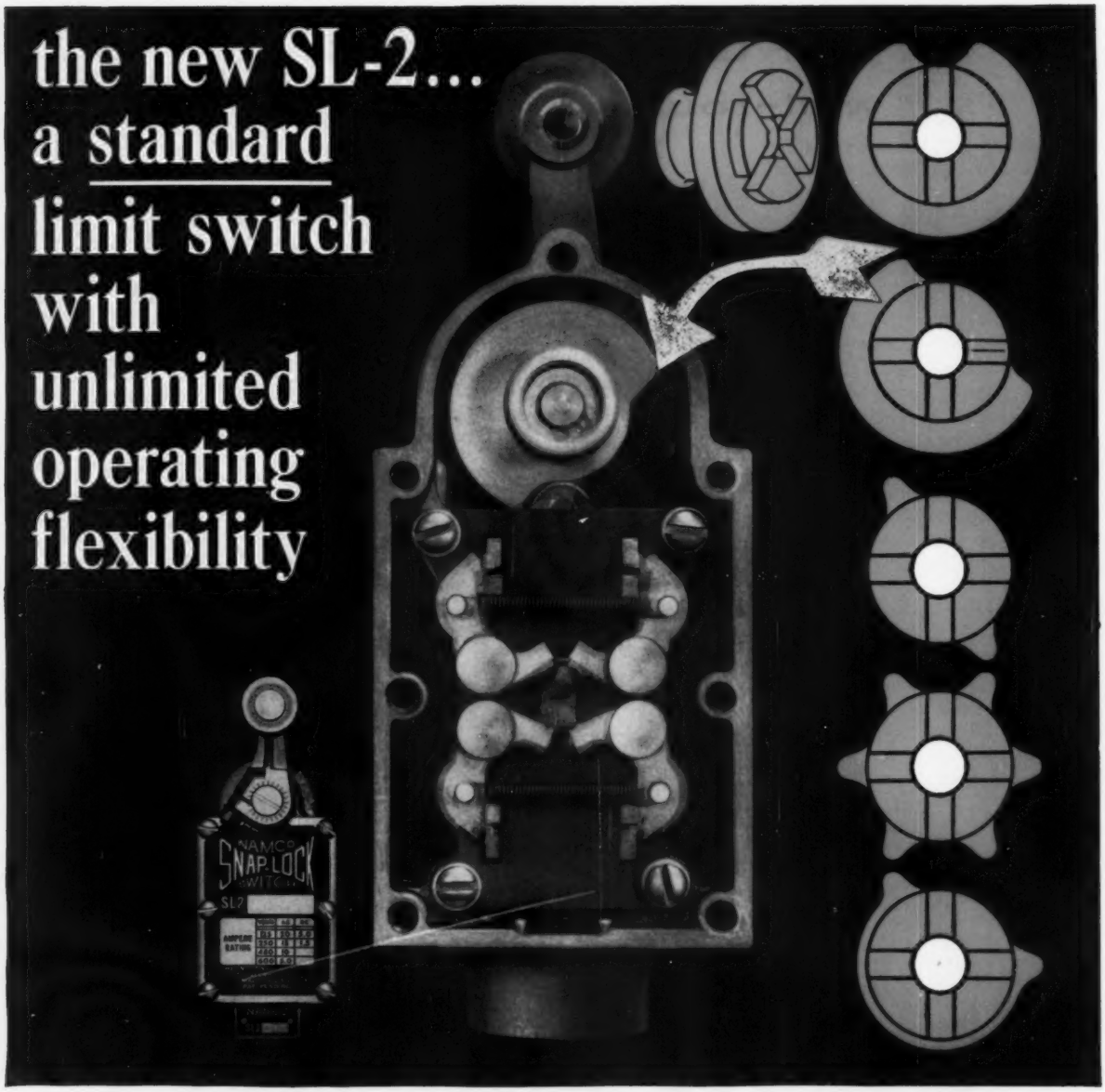
PLANTS COAST TO COAST

Circle 662 on Page 117

the new SL-2... a standard limit switch with unlimited operating flexibility



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Circle 663 on Page 117

Knowledge and Understanding

IN an effort to make the complexities of automation and labor more understandable to a meeting that included the Ladies Auxiliary of the Columbus, Ohio Chapter of ASME, we told the following story: Suppose you have a neighborhood business of selling rag dolls, and I work for you sewing them. I can sew one an hour. You pay me one dollar a piece and employ me eight hours a day. As an enterprising entrepreneur you dream of a larger, more profitable business.

Research in manufacturing methods leads you to the knowledge that the use of a sewing machine can increase worker productivity. A competent operator can turn out two an hour. When I learn of your plans, I am frightened about technological unemployment: 1. I have not been trained in the operation of a sewing machine. 2. Even if I learn the higher skill, I suspect you are the kind of schemer who would pay me one dollar an hour for making 8 rag dolls in the morning, and send me home at noon.

To allay my fears you explain the concept of expanding markets to me. Millions of squawking children are crying for rag dolls to hug. The growth curve of this business foresees our selling 16 a day. Enlightened and enheartened, I submit my new wage demand for $16.00 per day.

Further knowledge and understanding are in order. If you're going to use more capital equipment, there will be more stockholders, creditors, and equipment builders to pay, and more plant to buy. Salesmen must be paid to develop the market. Advertising and sales promotion expenses must be met. There will be employee training programs to finance. And last, but not least, the price must be cut to keep in line with competition from that haughty Mrs. Smith who is already using sewing machines. All this takes time.

There is much more involved than simply "Management" and "Labor." The whole free enterprise business system must be taken into account. Manufacturing technology is a key link in the system. Broader knowledge and understanding of how the system works are essential if organized efforts are to achieve progress in the public interest.

James C. Keebler

EDITOR

AUTOMATION

On-line computer control of an integrated line of production machines has been achieved in the manufacture of precision resistors. The computer exercises direct control over production scheduling, machine setup, and operating conditions in the production of many values of deposited carbon resistors. The authors outline the organization, philosophy, and technical problems involved in this manufacturing development.

COMPUTER-CONTROLLED MANUFACTURING SYSTEM

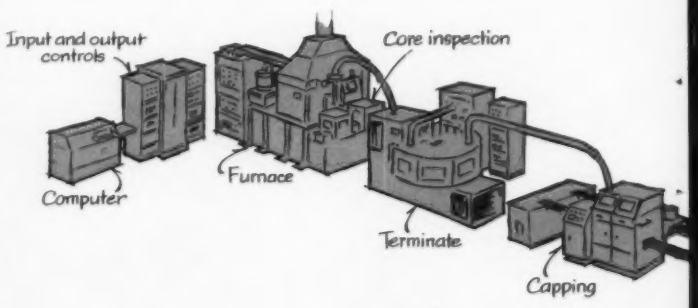
DEVELOPING A MULTIMACHINE COMPLEX

By J. D. SCHILLER and H. H. ARNOLD
Engineering Assistant Superintendent Engineering Department Chief
Manufacturing Development, North Carolina Works
Western Electric Co. Inc., Winston-Salem, N. C.

THE PRESSURE of technology has undergone an explosive change. In the last 10 years the annual outlays for research by business, government, and American universities have jumped from $2.5 billion to $10 billion, and this gigantic stimulus is just now beginning to heap its profusion of new products and new manufacturing methods into the economic hopper. With research spending still soaring and with science playing an even more important role, new developments will come so fast that the firm which coasts along with last year's technologies may well be committing economic suicide.

Experience has shown that mechanization and automation have created the need for a new high-level approach to the manufacturing problem. For economic success there is no alternative. A growing industry must partake in manufacturing development or face the risk of technical obsolescence. Nevertheless, industry invests relatively little in basic manufacturing research and the lion's share of its engineering investment is plowed into product development efforts. To complicate matters, there is a distinct lack of personnel trained to design, manufacture, install, control, and maintain highly mechanized or automated production systems. Industry is still concentrating on the competitive accumulation of premium *product* research and development talent while underestimating its need for *production engineering* professions.

The local management of the North Carolina Works, Western Electric Co. Inc., recognized this need and in the Fall of 1956 authorized the establishment of a manufacturing development organization. This group was initially staffed with two engineers. During the past several years one of the greatest satisfactions realized has been the development and creation of a seasoned manufacturing development engineering organization, coupled with the necessary allied supporting services and personnel. From the lessons learned by toil, trials, disappointments, and



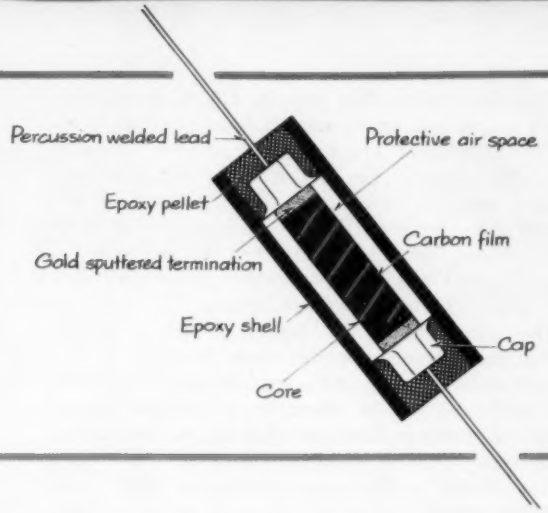


Fig. 1—Deposited carbon resistor consists of a short ceramic core which is coated with crystalline carbon. A conductive gold coating is applied to each end of the core for attaching a cap and wire lead. A helical groove is cut into the carbon film to change the electrical path on the core and raise the resistance to the desired value. The resistor is sealed in a plastic shell for protection.

hard-won accomplishments, this organization has gone through the exercises and disciplines necessary to acquire the vital ingredient—experience—and is now a valuable and seasoned team.

We are staffed with 4 manufacturing development engineering departments and one supporting department consisting of manufacturing development machine design and technical services. Technical services include a pool of highly skilled engineering associates, laboratory assistants, and the management personnel of extensive laboratory facilities. In another associated organization we obtain expedient production and ordering services and the assistance afforded by basic engineering laboratories such as chemical, metallurgical, spectrographic, electrical and mechanical standards.

The organizations are well integrated into respective project teams composed of a highly technical mix—the crossing of technological strains is as fertile in science as it is in botany. Different members of the group have different characteristics, different skills, and different personalities. As a simple example, some members are excellent process developers. When their mission is completed, they pass the project to expert machine or electronic systems developers to transform laboratory techniques into final manufacturing hardware suitable for production reliability.

A more crucial kind of help is that provided by an atmosphere charged with ideas. These ideas come from people, so this means bringing clever people with different backgrounds into contact with the group and encouraging the interchange of ideas. The individual is better at action while the group is better at judgment.

After many readjustments, movements, and refinements, our development group has shaken down into a free-wheeling, effective, hard-hitting combination which has been, and is being, "blooded" by actual development experience—experience for which there is no substitute. It is encouraging to see engineers professional motivation for their work as shown by their passing up of break periods, eating at odd lunch hours, and spending unsolicited time on development projects during evenings, weekends, and even vacation periods.

▶ Defining a Development Program

At present, we are primarily engaged in manufacturing development associated with basic electronic components. These components are in the most critical development areas due to their highly complex technological manufacturing processes, their primary effect upon the over-all reliability of elec-

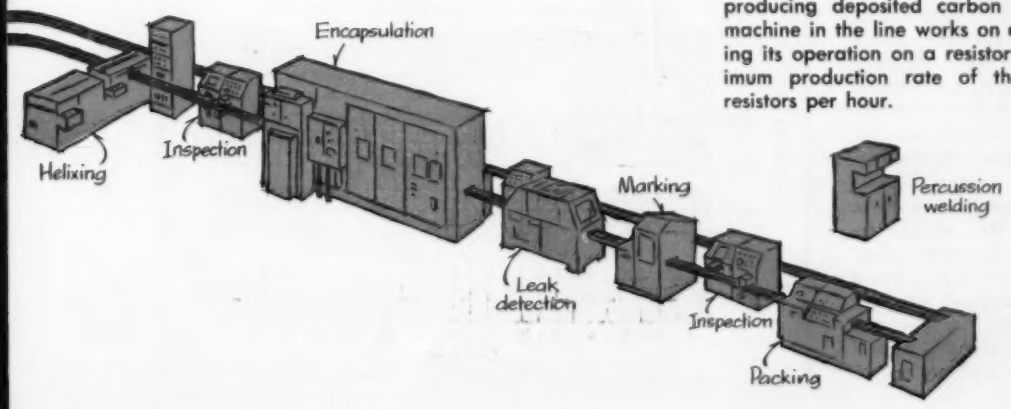


Fig. 2—Schematic of the automated production line for producing deposited carbon resistors is shown. Each machine in the line works on a 3-second cycle, producing its operation on a resistor during each cycle. Maximum production rate of the line is 1200 finished resistors per hour.

MANAGEMENT RESPONSIBILITIES FOR MANUFACTURING DEVELOPMENT

- Management must stimulate and direct interest in areas of activity which are potentially profitable to the company. This does not preclude opportunity for independent investigation, but it does assure that the major emphasis will be in areas that appear to have the greatest potential to the company which foots the bill.
- A good research organization relies on the ability to both pick and develop creative thinkers. Without these people, there can be no research and development. Everyone has some creative ability, but competition demands that research and development groups comprise the most creative minds available. Past performance is the best criteria of an individual's creative ability, but not the only one—other criteria are subtle and uncertain. Management must match its technical manpower resources against similar counterpart organizations in other competitive companies in selecting its creative people. Without these people, there can be no research and development.
- A young idea is a delicate thing. It must have a favorable environment to appear, and the necessary conditions are creative people and a seeking, or receptive, management. Management must establish a favorable environment for creative work. Policies, procedures, and facilities must be geared to the creative process. Facilities must be available to the research worker at a minimum of inconvenience on his part. Creative thinking flourishes best under conditions that allow freedom of action. These and other factors are important in establishing a favorable environment for creative efforts.
- Management must see that funds are authorized for research projects and that the funds are adequate for long-range development of company product programs.

tronic equipment whose integrity is so dependent on these small basic electronic building blocks, their potential high production volume, and their rapidly changing configurations based upon new scientific research backgrounds. One of our current development programs is the automation of manufacturing processes for ¼ to 2-watt deposited carbon resistors.

The deposited carbon resistor, *Fig.* 1, is a deceptively simple component used in large numbers in all of our electronic systems. It consists basically of a thin ceramic core coated with crystalline carbon, a metallic termination on either end of the coated core, hexagonal metal caps pressed over these terminations, wire leads attached to the caps; a helical groove cut into the carbon coated core, and a suitable moisture resistant enclosure.

The advantage of the deposited carbon resistor over a composition-type resistor is primarily its inherent stability, both with changes in temperature and with age. While conventional composition resistors may vary as much as 20 or 30 per cent under some conditions of exposure, deposited carbon resistors remain stable within a few per cent. This stability permits circuit designers to select electron tube and transistor circuits that permit individual circuit performance which is substantially higher than could be realized with less stable resistive elements. Thus, fewer active elements are required for given performance specifications. This reduction in active components enhances the reliability of systems, and demands for these resistors have increased tremendously as reliability specifications have become tighter and systems have become more complex.

As demand for these resistors increased, requirements for improved reliability of the deposited carbon resistor itself were felt. Several years ago it became apparent that the combination of larger production requirements and higher reliability for resistors to be used in our military systems would require major changes in our normal manufacturing techniques.

Analyses of sources of unreliability in resistors then manufactured indicated several significant facts. These were eventually reduced to the following development guides:

1. Reliability stems from consistent, controlled manufacture of a design compatible with military environments and used with adequate stress margins.

2. Contamination, whether through human handling or airborne sources, is a prime enemy of resistor reliability.

3. Organic coatings in contact with a carbon film are a proved source of unreliability.

4. Thin or narrow spots in a carbon film path are a source of unreliability.

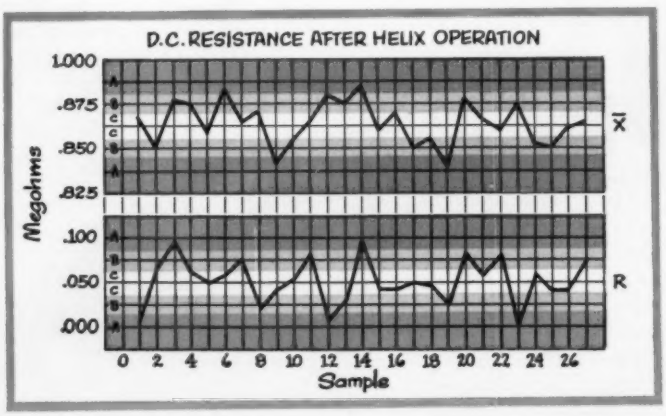


Fig. 3—Manually-plotted statistical quality control chart records dc resistance after a manual helixing operation. Individual averages, *X*, and ranges, *R*, are plotted. Application of nonparametric tests established by statisticians determines whether the data plotted represents only random variations in a statistically normal distribution or whether the data truly indicate a trend. Tests applied in this manner include the following: Any 8 points occurring on either side of *X*; any 3 of 5 points occurring in zone "B" or beyond; any 2 of 3 points occurring in zone "A"; or any single point occurring beyond the control limits. The range chart is similarly tested.

5. Built-in reliability is preferable to the type achieved by "screening" or "sorting" procedures.

These principles led not only to considerable change in the design of the resistor itself but also pointed inexorably to automation as the method of manufacture. The necessity for near perfection, both in handling and in manufacture, virtually eliminated the possibility of proper process control under normal manual manufacturing methods.

A development organization was formed to study, plan, and co-ordinate the necessary product, machinery, and control equipment for accomplishing this project. As investigations progressed, rather firm requirements began to emerge in the area of product, machinery, and control.

The requirements for the product were: 1. The film should be free from any organic coating. 2. An enclosure for the resistor must be devised which would be highly impervious to moisture yet economical to manufacture. 3. An improved method of lead attachment compatible with automated production must be found. 4. Requirements must be established which would minimize the possibility of latent defects occurring in the final output.

The requirements for machinery established at this point were: 1. Cycle times must be arranged to be compatible between all machines, with an objective of 1200 parts per hour as a desired goal. 2. Material handling in and between all machines must be fully automatic and arranged so that parts would not become contaminated. 3. Inventories between operations must be kept at a minimum so as to facilitate automatic control. 4. All machinery must be capable of handling an infinite number of electrical values without manual changeover, as well as four physical sizes of resistors. 5. Completely unattended operation of each machine was required.

The control requirements then apparent were: 1. Completely automatic setup of each machine was needed. 2. Feedback control at three critical points in manufacture would be required. 3. Inventory control was necessary so as to be able to recognize rejections occurring at individual stations and compensate for these by manufacturing additional units.

▶ Implementing the Program

Once the product, machinery, and control requirements had been roughly defined, many challenging problems in all three areas could be foreseen. Before these problems are discussed in detail, a general description of the automated production line in its final configuration is necessary in order to orient one with the location and use of each piece of equipment under discussion. For this purpose, a schematic portrayal, *Fig.* 2, illustrates the location of equipment and the process flow.

The first step in the process is the coating of ceramic cores which are fed by vibratory hoppers into a coating furnace. A carbon coating, deposited on these cores in the high-temperature furnace, creates the resistor element. Upon discharge from the furnace, the coated blanks are inspected at the core measurement station, and data is fed back to a computer. Feedback control of the core speed and/or coating gas concentration in the furnace is determined by the computer. Accepted cores are then transported by pneumatic tube to the terminating machine. Here, a gold band, ten millionths of an inch thick, is deposited on each end of the core by vacuum sputtering.

The next step in the process is that of fitting cap-lead assemblies over the resistor body. The resistors are then automatically placed on pallets for conveying through the remaining operations. They are transported by means of a demand feed conveyor system to the helixing station. At this station the value of the resistor is increased by cutting a helical groove in its surface until the required final value is reached. An inspection station, following helixing, serves as a feedback control point to the computer so that correction of the helixing lathe monitoring bridge can be made. This correction maintains the nominal value of the resistor at a properly centered point between its specified limits.

The next step is that of automatic encapsulation, followed by leak detection. A marking machine, also set up by the computer to the required resistor code, then identifies the product. It is next passed to the final inspection station where accept-reject tests are made, and feedback information is again sent to the computer. The final station is that of packing,

MISSION AND RESPONSIBILITIES OF A MANUFACTURING DEVELOPMENT ORGANIZATION

1. Disclose to management manufacturing opportunities revealed by research investigations or suggested by scientific advances. These opportunities serve as a background for decision making relative to feasibility and practicability of new product and manufacturing concepts.
2. Evaluate areas of scientific endeavor to isolate opportunities for further work in manufacturing techniques. Evaluation must also assess the potentials and limitations of each area.
3. Define areas of manufacturing significance and stimulate the recognition and formulation of problems in the areas of company interest.
4. Select the most promising areas and establish priorities based on limitations imposed by time and budgets.
5. Assess development proposals in terms of manpower, methods, and facilities required.
6. Implement the selected programs.
7. Develop needed technology as rapidly and as efficiently as possible.
8. Reassess problems during the course of solution to evaluate necessary changes in methods, manpower, and facilities as work proceeds.
9. Abandon projects that are not productive or that should be displaced by more promising programs.
10. Co-operate with other organizations in the effective introduction and utilization of new technology.

either for further processing or for direct shipment.

The area which perhaps represents the major innovation in the manufacturing development is that of automated control of the production line. Servo specialists were quick to recognize that a long control loop, involving many manufacturing operations, posed serious problems. Besides a long elapsed time between cause and effect, in many instances there could be variable delays in which bad process inventory could be made between occurrence of the damaging effect and the opportunity for its measurement.

A prime example of this type of delay appears in the coating furnace where crystalline carbon is applied to the resistor core. Considerable delay exists between the application of a signal intended to change the gas flow in the coating chamber of the furnace and the actual arrival of the changed gas mixture, which causes a gradual change in resistance value. Another finite delay period exists between the emergence of the resistor from the coating zone and its appearance, for measurement at the core measurement station. Thus, conventional analog control techniques appeared virtually useless because of the very low gain, low frequency response circuits which would have to be employed.

After considerable study of this problem, the techniques of statistical quality control emerged as a possible solution. For example, in manual manufacture, data are manually plotted on an appropriate control chart, *Fig.* 3, and an analysis is made to indicate when significant trends are present. Only when such trends appear is corrective action taken, thus preventing many false starts and erroneous conclusions which might ensue if action were taken based on the result of a single sampling.

INITIATING MANUFACTURING DEVELOPMENT PROJECTS

- Stimulate and co-ordinate development of processes, materials, and associated equipment in connection with the manufacture of present and future designs. This objective can be accomplished through the media of a Cost Reduction and Manufacturing Development Committee.
- In areas of improving present, or applying new, manufacturing processes to existing shop products, a development introduction should be subject to request for this service. Where the development is self-motivated, it should be conducted based on approval and negotiated agreements with the cognizant line engineering organization.
- In areas of future manufacturing needs, maintain close co-ordination with product design organizations on new products requiring manufacturing development for production application. When managerial concurrence is reached, proceed with the development. When the product reaches the stage of production requirements, phase into manufacture with the associated line engineering and operating organizations.

The basic problem of applying such techniques to automated production is that of speed. Manual plotting of such a chart requires considerable time and manpower. In addition, the possibility of human error in performing the large number of calculations involved in a program of this sort offers the possibility of serious errors, affecting the reliability of the product. Thus, the use of a high-speed digital computer for performing this task appeared as a solution to this problem. It also could provide a large data storage medium which was desirable in handling other requirements of the control system such as setup, inventory control, and production control demands.

A survey of the available computers at that time pinpointed the Librascope LGP-30 (marketed by Royal-McBee Corp.) as an available system in the desired size, memory capacity, and price range. This computer, equipped for keyboard input-output, was not directly applicable for our use, but our design of suitable input-output equipment for attachment to the computer made it feasible for on-line use as contemplated. The complete control complex is shown in *Fig.* 4 in its final form.

The characteristic method of applying crystalline carbon to resistor cores has been to place a large number of ceramic cores in a quartz bottle, insert this bottle into a high-temperature furnace, and introduce methane gas at a controlled flow rate. As the cores are stirred by rotation of the quartz flask, they become coated with crystalline carbon.

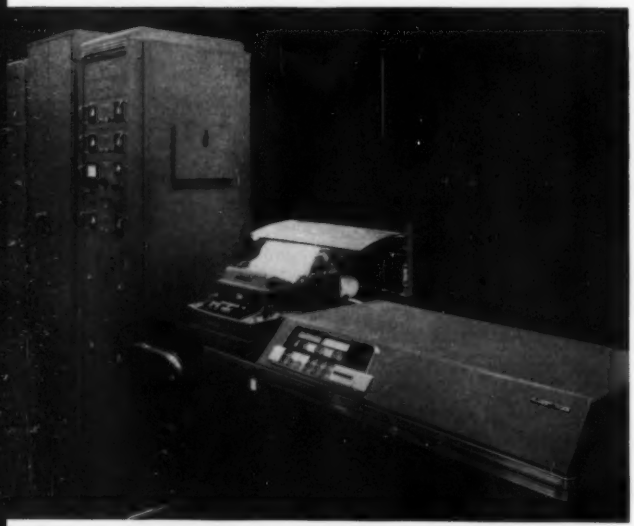


Fig. 4—Computer control complex for the automated line is shown. In the right foreground is the digital computer. To its left is a keyboard for the input and output of data to the system. In the left background are three control cabinets which contain specially designed input-output circuits to enable the computer to program, set up machine stations, and control many of the operations in the line.

Because of a rather wide dispersion in resistance values of the cores within the flask, it has been necessary to sort the cores by resistivity before further manufacturing is done. This method appeared highly unsuitable for the kind of control which we hoped to exercise.

It was decided to begin our operation with a coating furnace that would coat each core separately and to continuously control the operation of the furnace based on measurement of the output product. The internal structure of the resulting furnace is shown in *Fig.* 5. The cores, supported on rotating rods, are fed individually through the furnace and are coated by the injection of methane gas into the coating zone. The internal ceramic structure of the furnace was a matter of some concern, involving a careful selection of experimental materials in order to obtain adequate life under the severe conditions of temperature and mechanical strain. The control of gas flow to the coating zone also posed a serious problem.

A plot of resistance values versus gas flow is shown in *Fig.* 6*a*. It will be noted that at high resistivity a very small change in gas flow represents a very large change in resistance. Therefore, it is necessary to have both a high degree of resolution and a high degree of stability in the valves and orifices which control the gas. The stability is accomplished by the use of a servo control which drives a precision valve under the influence of a sensitive pressure transducer. The high resolution is obtained by a binary valve arrangement, *Fig.* 6*b*, which uses sintered bronze orifices, selected to give resolution in excess of 1 part in 10,000. Each orifice selected provides a flow of exactly twice that of the next smaller orifice.

▶ New Approach to Termination

A major physical problem involved in the automation of deposited carbon resistor manufacture is that of providing the low resistance metallic terminations for the resistor. These terminations have been applied historically by the application of a silver paint in an organic binder. After a suitable baking operation, ranging up to 16 hours, these terminations have been quite satisfactory. However, the prospect of such an extended curing cycle made our feedback control loops appear extremely impractical. Accordingly, our first approach was to find means for accelerating the cure.

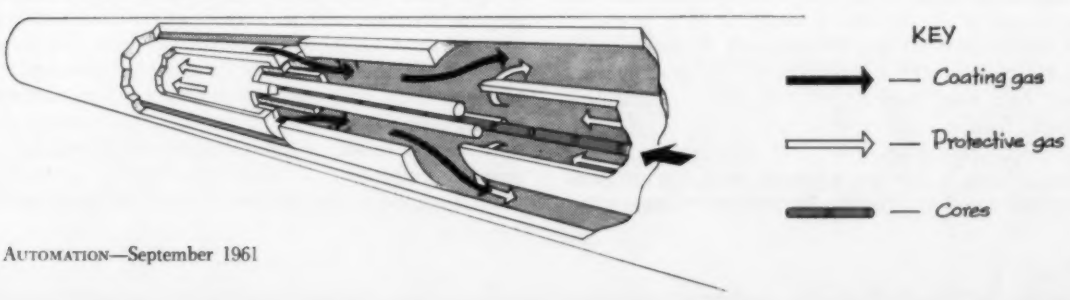
Various resins were tried in an attempt to develop an accelerated curing material, and the curing cycle was reduced to as little as 1½ hours. However, this still appeared to be an excessively long interval in which to accomplish effective feedback control. The application of metal by the Schoop process of metal spraying was explored, but was abandoned because of the possibility of contamination of the resistor during this operation. Soldering the lead directly to the carbon by means of a silver-copper-titanium alloy was explored, but was also found unsuitable because of the high order of vacuum required in order to prevent damage to the carbon.

Advances in the application of thin films by sputtering had attracted our attention, and this idea was explored as a possible means of applying a conductive termination to the resistor itself. This technique appeared desirable due to the comparatively poor vacuum required for this work, the rapid rate of deposition that could be accomplished, and the cleanliness of the operation. After considerable work with several basic metals, the design of the resistor that finally evolved was one using a sputtered gold termination. The final machine, *Fig.* 7, is the ultimate result of this decision.

The cap-lead assembly which was used previously in resistor manufacture consisted of a brass ferrule in which a square hole had been cut. A tin-plated copper wire was swaged into this hole to provide a mechanical bond, and the parts were soldered for electrical conductivity. In the introduction of automated equipment for handling the cap-lead assembly, it became apparent that if the cap-lead assembly were soldered before affixing it to the resistor, it would pose a serious handling problem, both in capping and in helixing. On the other hand, if soldering were accomplished after helixing, then the possibility of contaminating the finished resistor with splashes of solder or with flux became important.

This dilemma led us to a process of welding the cap-lead assembly. Utilizing techniques developed at our Hawthorne plant, a highly reliable weld was obtained. Therefore, a machine was designed and built at Hawthorne that provided the basis for an exceptionally secure lead attachment. This operation is accomplished off the production line since the machine output can supply more than one production line. The welded assemblies are

Fig. 5—Sketch illustrates the interior construction of the coating furnace. A horizontal 3-roller support system rotates the cores as they are pushed by external means through the furnace. Inert nitrogen gas is continually supplied to prevent oxygen contamination. Methane gas is decomposed at a temperature of over 2000F to form crystalline carbon on the cores.



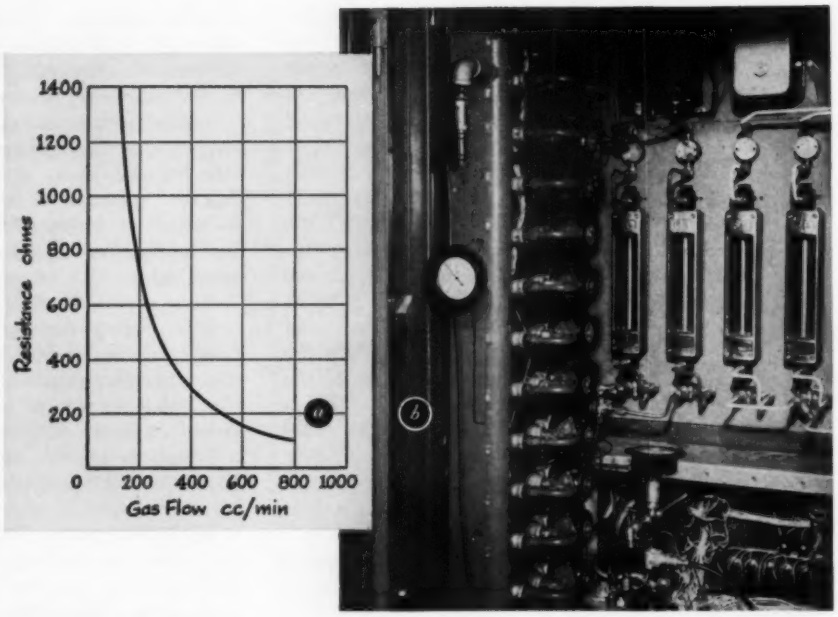


Fig. 6—A plot of core resistance values obtained at various methane gas flows is shown in *a*. When producing cores of high resistance, a very small change in gas flow causes a large change in resistance. Under control of the computer, the methane gas flow to the coating furnace is precisely varied by means of the 11 servo controlled valves shown in *b*. High resolution is obtained by using a binary valve arrangement. Each valve has a sintered bronze orifice which is selected to provide a flow of gas that is exactly twice the flow of the next smaller orifice.

placed in vibratory bowl feeders on the automated resistor line and fed to a machine which automatically installs the cap-lead assemblies onto the core blank. Due to the high force involved in fitting the caps onto the core, the compatibility of gold plating applied on the cap, and the gold termination previously applied by sputtering, fusion occurs during this operation so that the cap and core are actually welded together.

Variable Helix Problem

In order to arrive at a suitable time cycle for the over-all operation of the line, it became apparent that a bottleneck operation was likely to occur at the helixing machine. Here, a helical groove, varying in pitch from a fraction of a turn per inch to 60 turns per inch, had to be cut in the surface of the ceramic core without chipping and with a total cutting time of approximately 2 seconds. Cycle times of approximately five times this value were then being used throughout industry.

Automatic adjustment of pitch is required so as to permit manufacture of different resistance values from the same size core. Our initial objective was to have a limited number of discrete pitch settings in order to accomplish this adjustment, the fine variation of various individual final resistor values being provided by adjustment of coated blank values at the furnace. This objective was accomplished by using a servo control positioner to control a variable speed drive attached to the helixing lathe, and its use permitted 22 individual values of helix pitch.

Concurrent with the development of the helixing machine, however, a prototype of the coating furnace had been constructed. It soon became apparent that a considerable time interval was involved in changing from one core value to the other. Thus it became apparent that a significant economy could be effected by making a large number of final resistance values from a single core value so as to minimize the number of changeovers required at the furnace. To do this required a much greater resolution of pitch adjustment than had been previously contemplated, in fact, several hundred individual settings of pitch appeared desirable. Therefore, the pitch adjusting servo was abandoned, and an alternate solution was devised.

Independent drives were provided for both the mechanism which traversed the carriage of the helixing machine past the cutting wheel and for the spindle rotating the resistor being cut. The traverse motor is a synchronous motor so that the carriage always traverses at a constant rate of speed. A specially designed magnet permits the accurately balanced carriage to follow the cutting wheel closely, regardless of surface irregularities in the carbon coating and the ceramic core. It is then only necessary to provide a binary voltage divider under computer control to set the speed of the variable speed motor selected for rotating the resistor. This has the additional advantage of giving a fixed time cycle for each resistor, regardless of pitch.

Sealing the Resistor

One of the most interesting problems encountered in the development of this line was that of encapsulating the resistor. Resistors had previously been protected from environment by a technique of spray coating the core with a lacquer and then enclosing the resistor in a loose-fitting plastic sleeve for purposes of physical protection. This protection was minimal at best, and in instances where temperature cycling caused cracking of the lacquer coating, almost certain failure of the resistor resulted when exposed to moisture.

In evaluating the problem, the cost of ceramic

enclosures, or of glass enclosures, appeared forbidding, and it was elected to pursue a molded or plastic enclosure for this application. This work originally included exploration of composition and transfer molding of alkyds and diallyl phthalates. While providing reasonable protection from environment, these molding compounds had the disadvantage of having to be in direct contact with the carbon and causing considerable shifts in resistance value during the molding operation and in later temperature cycling. A design was then devised involving a piece of Kel-F tubing which was heat-sealed to each end of the resistor assembly. This technique provided a remarkably superior product except that great difficulty was encountered in obtaining a satisfactory seal at the resistor ends. Surface treatment of the parts, surface treatment of the Kel-F tubing, special heating techniques, and special chemical environment during the seal were extensively explored before this approach was reluctantly abandoned.

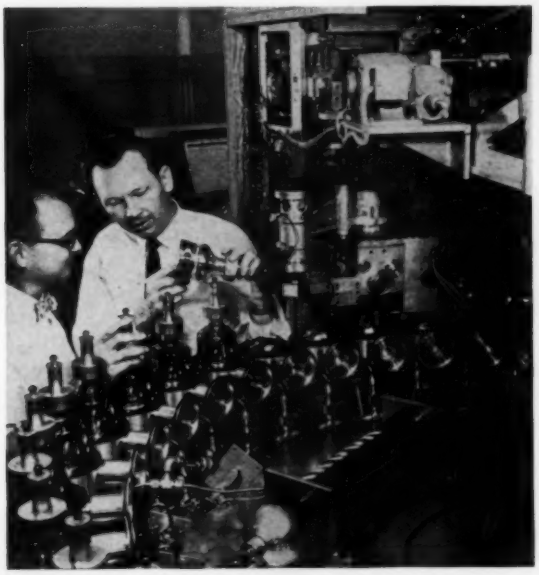


Fig. 7—Interior construction of the terminating machine is shown. Coated cores from the coating machine are automatically fitted with masking fixtures and loaded onto one of the 36 positions of a rotary indexing table. A bell jar is lowered over the core and mask, and the unit is pumped to a vacuum as the table rotates. The bell jar is then backfilled with argon gas, and particles of gold are sputtered on the ends of the core from a gold cathode in the neck of the jar. During the sputtering operation, the mask containing the core is rotated by two rollers which are actuated by an external magnet coupled through the vacuum seal and a suitable gear train.

At this time an epoxy product appeared on the market that, although initially solid in nature, first softens and then hardens upon application of heat. This material was formulated into small cylinders that were placed on each end of a resistor inside a tube fitted around the resistor. The resulting product appeared to offer considerable possibilities except that expanding air inside the resistor enclosure often caused a small bubble to appear in the softened epoxy, thus leaving a void and sometimes a hole in the seal. Elaborate pressure-balancing techniques and controlled heating cycles were tried. Finally, a scheme was evolved where a temporary air seal was made at each resistor end by retaining the resistor between resilient rubber chucks during the heating operation.

Another interesting problem relates to the detection of imperfect seals in the encapsulating operation. Because of the enclosed air space in the resistor assembly, it appeared possible to make a test to prove the effectiveness of the seal. Helium-type leak detectors and radioactive detectors were initially explored for this use. Since we desired a short time cycle and these types of detectors are conventionally employed in batch-type operations, they did not appear suitable for this application.

A device, *Fig.* 8, was developed which employed hot oil to cause expansion of the air inside the resistor and thus cause bubbles to develop in the oil in the event of a leaking resistor. The change in the dielectric constant of the oil due to the presence of air bubbles caused a measurable change in the detection equipment, thus permitting rejection of any leaking resistor. However, application of this technique indicated the necessity of cleaning the resistor after leak detection in order to eliminate the oil from its surface.

Because of this difficulty, it was decided to attempt

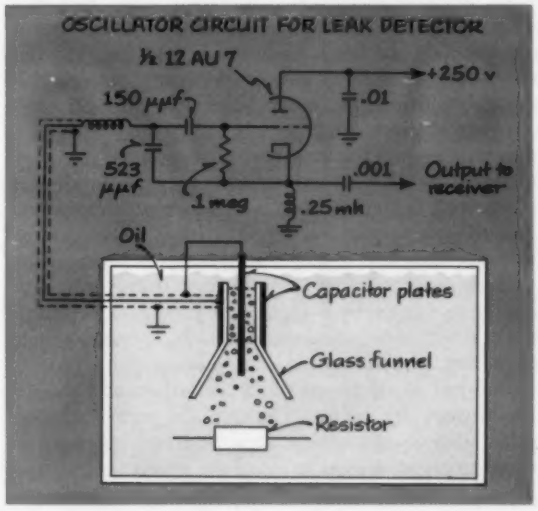


Fig. 8—One of the preliminary designs of a leak detector for detecting resistors with defective plastic enclosures is shown. In this device, hot oil caused the air trapped inside the plastic enclosure to expand and escape through any small holes left in the covering. The rising bubbles of air caused a change in the dielectric constant of the oil that was measurable with instruments.

using water and photoelectric-type detection in order to avoid the cleaning problem. A suitable wetting agent for the water, together with improved sensitivity of existing photoelectric detection equipment, permitted satisfactory operation. However, glycerin, which had been initially selected as a wetting agent, greatly hindered the marking of the resistors in a later operation. Conventional detergents were found to adversely affect the appearance of the sealed epoxy pellet on the resistor. After considerable exploration, a photographic wetting agent was adopted and appears satisfactory.

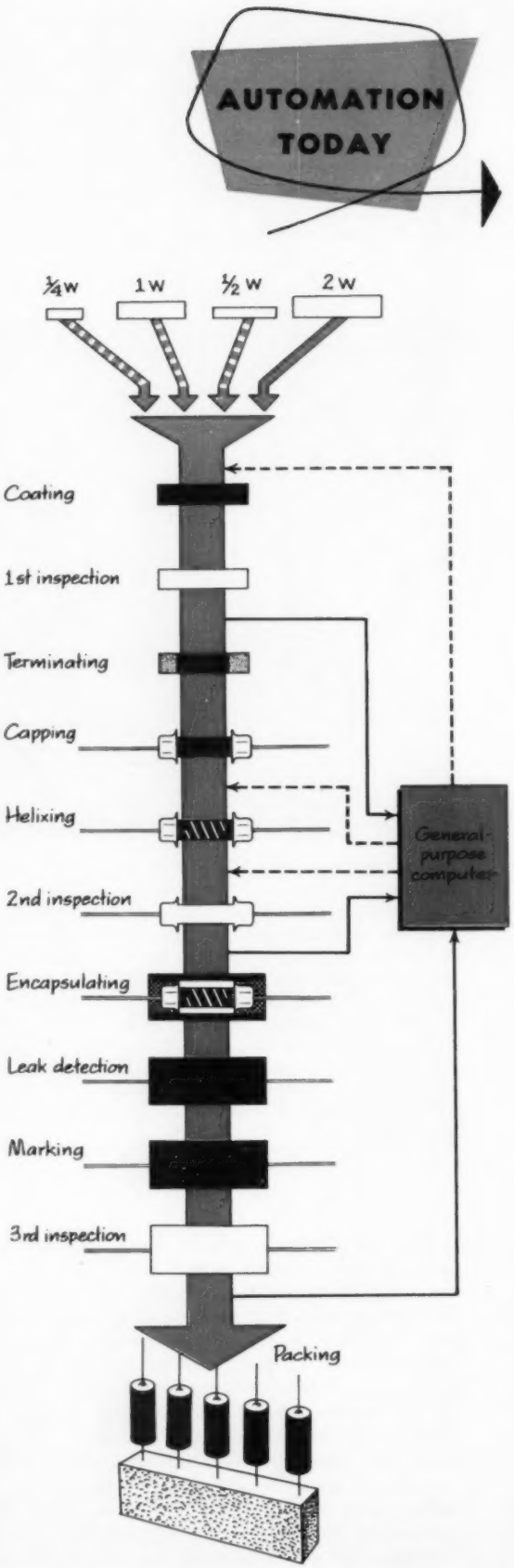
▶ Challenges of Automation

We are of the opinion that this achievement represents a unique technological breakthrough wherein an entire discrete product manufacturing facility is controlled by a computer and utilizes the application of statistical quality control analysis for sensing and self-correction in order to afford consistent controlled manufacture of a precision electronic component. This step affords the feasibility and leads the way to other similar manufacturing applications of a variety of other discrete products.

A description of all the problems encountered in this development would be beyond the scope of this presentation. However, the few problems discussed represent the challenges faced by our engineers in creating an automated deposited carbon resistor production line. Automation, as represented by this development, is not a revolutionary technique but a continuation of our progress in mechanization. The essential feature in this new step of mechanization is the application of electronics to control all types of manufacturing processes. The electronic computer is the central feature of this development and is the practical application resulting in the substitution of mechanical, or electronic, controls for manual controls at many points in the physical processes of production.

In this respect, automation is essentially the continuation of the scientific management movement which took shape 50 years ago. Current impressions that the automatic factory is arising solely out of new machinery and new controls are erroneous. This concept ignores other key factors that contribute greatly to automation—design of product (including mix), production processes, materials, factory layout, marketing, maintenance, and management. Automation has its advantages and limitations and should not happen by accident or for the mere sake of technical accomplishment. It should be implemented where applicable as a result of an economic integration of product development, materials development, production development, and market development.

One of the outstanding conclusions one might reach is that automation places a great premium on managerial planning. Manufacturing management has a new role to play. This role is that of a "machine designer" with the factory becoming an integrated machine which is conceived, built, operated, and maintained by highly skilled personnel.



COMPUTER-CONTROLLED MANUFACTURING SYSTEM

MAKING DEPOSITED CARBON RESISTORS

OVER-ALL INTEGRATION of many historically separate facets of operation into a single automated production system has been accomplished at the North Carolina Works of Western Electric Co. Inc. These facets include automatic product manufacturing consisting of material deposition, machining, assembly, encapsulating, marking, and packaging operations; automatic inspection of product with the provision of rejecting bad product; automatic machine set up when product parameters are changed; and continuous statistical control of production through analysis of inspection data. All facets are under direct control of an on-line electronic digital computer.

The production system is 110-feet long and consists of eleven machines—eight operating and three inspection—used in the automated manufacture of deposited carbon resistors. These precision resistor components are used in large numbers in a variety of electronic equipment for military and Bell Telephone systems. Maximum production rate of the system is approximately 1200 resistors per hour in power sizes of ¼, ½, 1, and 2-watt. The process begins with the deposition of crystalline carbon on a purchased ceramic core. The core then moves progressively through inspection, termination, capping, helixing to value, second inspection, encapsulation in a protective casing, marking, leak inspection, final inspection, and packaging.

Heart of the automated production system is a Librascope LGP-30 digital computer (marketed by Royal McBee Corp.) which provides on-line control of the entire line. Western Electric engineers modified it, adding input and output circuits so that it could control the programming, setup, and feedback control of individual machines in the system. Basically, the computer performs in three areas: Production control, quality control, and setup control.

1. **Production control.** A month's requirements for resistors can be fed into the computer at random by means of a keyboard or punched tape. The computer sorts out the separate orders, groups the resistors according to the four basic power sizes, accumulates resistance values of each power size into an orderly production sequence, and schedules the sequence in which the various power sizes and resistance values will be processed.

2. **Quality Control.** Using methods of statistical quality control, the computer analyzes control data accumulated at the three inspection stations in the line and applies statistical tests to determine if a deviation trend is developing. No control action takes place while this analysis indicates a normal statistical distribution around a desired nominal. When a trend away from accepted manufacturing tolerances develops, the computer uses stored data to calculate new setup information for the appropriate station.

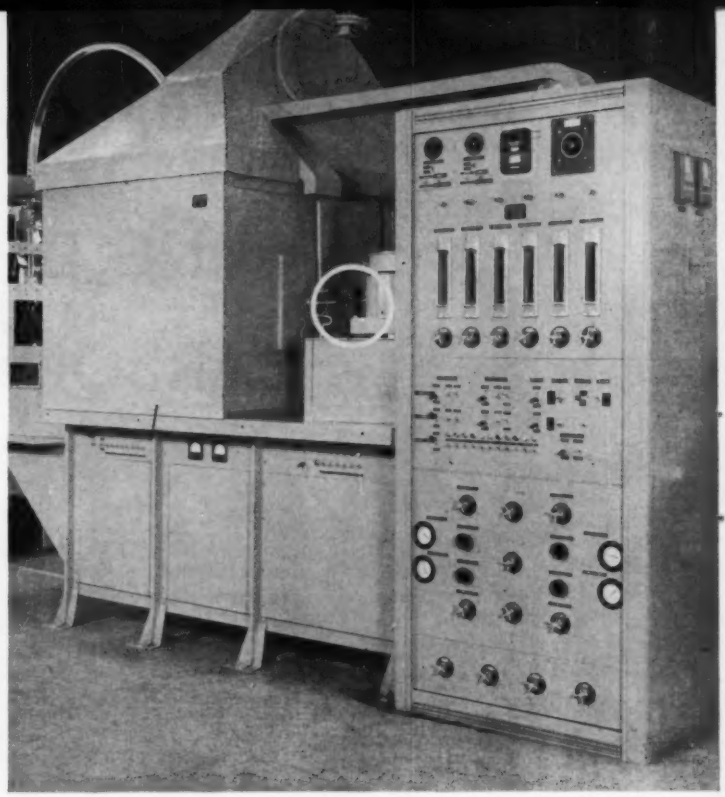
3. **Setup control.** In addition to feedback control functions, the computer provides initial setup of wattage size at eight machines and setup of resistance values at six machines.

Time sharing of the input equipment and of portions of the output equipment helps to conserve apparatus in the computer system. The computer output is stored in transistorized registers and setups such as wattage size, gas flow, and core speed require binary registers for each machine. Those machines requiring decimal setup—helixing machine, marking machine, and two inspection storage bridges—share a single binary coded decimal register. The input unit is an analog-to-digital converter. Although it is time shared between the individual input stations, the 140,000 bit-per-second speed at which it sweeps data into the computer precludes any delay in the computer operation.

Computer control of the automated system first occurs at the coating furnace at the beginning of the line where ceramic cores are coated with crystalline carbon to form a resistance element. Three parameters govern the value of the resistance coating: The speed of the core through the coating

1

Flow diagram illustrates the processing steps for making deposited carbon resistors on a computer-controlled production line. The line consists of 11 machines, each of which is connected into a digital computer for control actions. Statistical quality control data is fed back from the 3 inspection stations to the computer which determines if there is any drift from accepted manufacturing tolerances. When a deviation trend develops, the computer uses the data to compute corrective setup information for the appropriate station. In addition to feedback control functions, the computer provides initial set up of wattage size at 8 stations and set up of resistance value at 6 stations.



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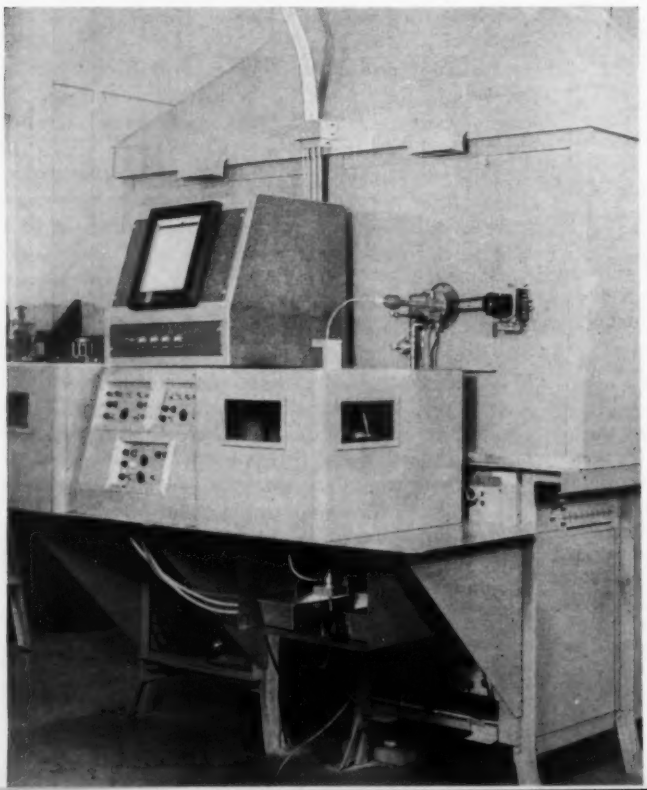
Many hundreds of resistor values are made from four basic sizes of ceramic cores—¼, ½, 1, and 2 watts. Each size core is stored in its own vibratory bowl feeder unit, and the four feeder units are mounted on the machine in a "ready" condition. When a particular size is being run, the computer activates the necessary switching controls to trigger the feeding of the correct core size into the deposition furnace. The vibratory units feed the cores to a core drive, black rectangular unit, which pushes the cores through the three-chamber coating furnace, left. As the cores are pushed through the furnace, they are continuously rotated on a horizontal, 3-roller support system to assure uniformity of coating. Inert nitrogen gas is continually supplied to prevent oxygen contamination, and a temperature of 2000F decomposes methane gas to form crystalline carbon on the cores. The cores are then cooled to room temperature and pushed to the first inspection station, left end of the furnace. The large control panel on the right contains the computer-controlled methane gas controls, the nitrogen gas controls, and the controls for the vibratory feeders and core pusher drive. A second coating unit is built directly behind the unit shown and is also controlled from the panel.

zone, the pyrolysis temperature, and the flow of methane gas. The computer controls these parameters by means of a data feedback loop from the first inspection station which immediately follows the coating furnace in the line. At this station the coated core passes between four probes using the Kelvin bridge principle. Analog voltage proportional to resistance is digitized and fed to the computer memory drums where it is stored and sampled on a statistical quality control basis against programmed requirements, also stored on the memory drums. The computer calculates the data, and, if a correction is necessary, the computer actuates solenoid operated digital flow valves on the furnace to control the



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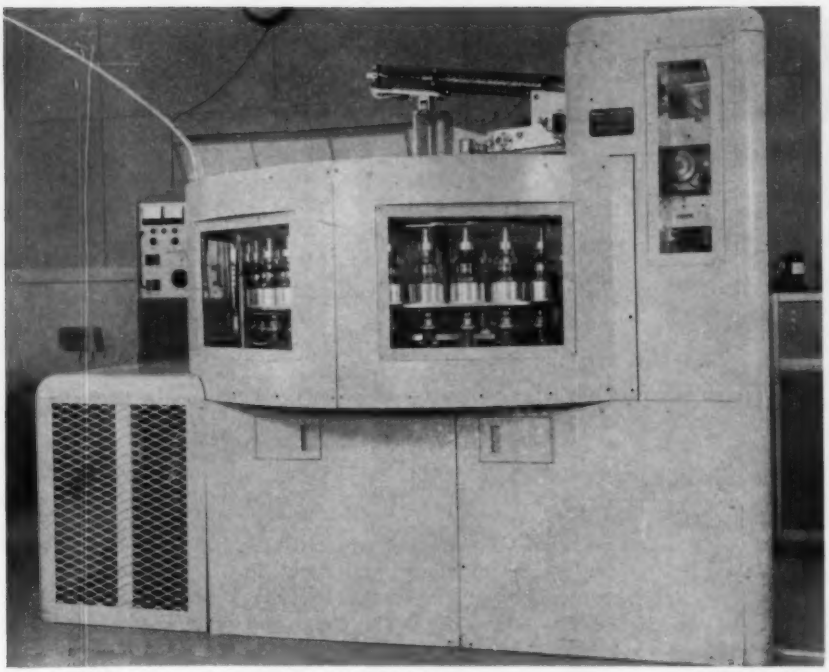
The first inspection station is part of a feedback control loop between the coating furnace and the computer. Coated cores are pushed from the furnace through the projecting pipe, center right, are guided around a 90-degree bend, and feed into the inspection station. Results of the inspection form the basis for feedback control of the furnace, and a recorder makes a record of the tests for visual monitoring. Out-of-limits cores are rejected into the pan below the station while acceptable units are blown pneumatically through overhead tubes to the terminating machine. To separate different lots of resistors, the computer also causes the station to insert magnetic slugs into the pneumatic tubes at the end of each run.



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Coated cores enter the terminating machine at the extreme upper right. Each core is then fed to a pick-up station where it is fitted with a masking fixture. The fixture is then loaded onto one of the 36 stations of the rotary indexing unit and covered with a bell jar. As the unit indexes, the bell jar is pumped to a vacuum and then backfilled with argon gas at low pressure. The ends of the core protruding from the mask are then sputtered with particles from a gold cathode. The sputtering lasts for almost a minute, depositing a layer of gold approximately 0.000010 inch thick. The gold is deposited uniformly on the core due to rotation of the core. After sputtering, the cores are unloaded from the masks and blown by pneumatic tubes, upper left, to the capping machine.

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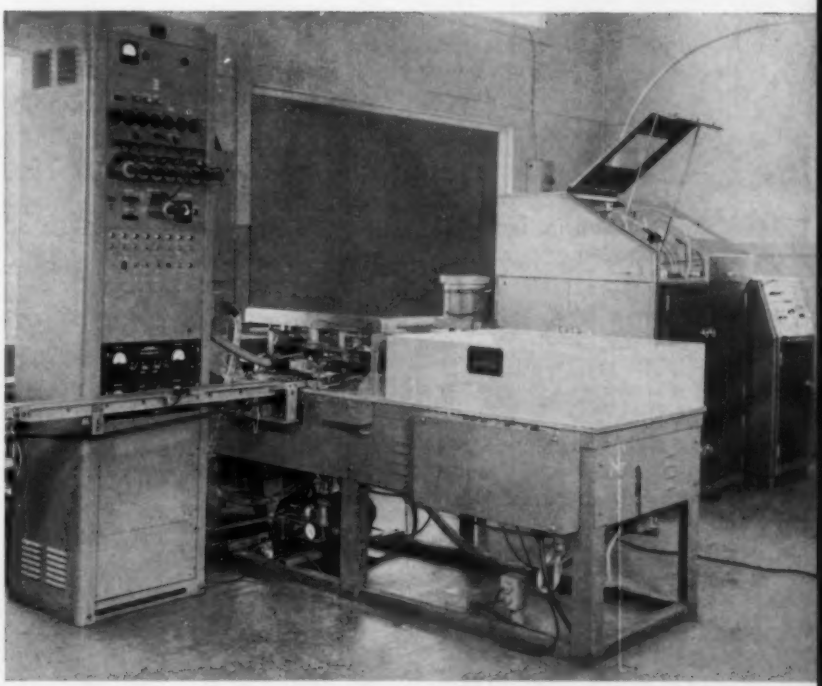


This view shows the capping machine in the right background and the helixing machine in the left foreground. An automatic machine off-line percussion-welds a solder-coated wire lead to a gold-flashed brass cap at a rate of approximately 3600 assemblies per hour. The cap-lead assemblies are brought to the capping machine and loaded into vibratory bowl feeders at the rear of the unit which feed the assemblies into capping chucks. Resistor cores, blown from the terminating machine by pneumatic tube, are loaded into a turret which holds a core in position as the capping chucks simultaneously press the cap-lead assemblies over both ends. The machine operates on a demand basis so that the arrival of a core automatically triggers the capping operation. After unloading, the capped cores are conveyed on individual pallets by a continuously-running belt to the helixing machine, left foreground. The helixing operation is accomplished "dry" in about 3 seconds. Control circuits in the machine sense non-linear change of resistance, indicative of chipping or thin spots in the carbon coating, and reject defective cores. The circuits also reject any resistor that reaches full value before 75 per cent of its length is used or any resistor that fails to reach value in its available length.

gas flow in the coating zone.

After inspection (and rejection if necessary) the coated cores are blown through pneumatic tubes to the terminating machine where a gold contact is sputtered over each end of a core. During the sputtering operation, each core is held in a mask which protects the center of the core from over-sputtering. Since there are four different sizes of cores used in the system, the computer is used to program the proper mask size when the machine switches over to different core sizes.

The next machine in the system is a capping

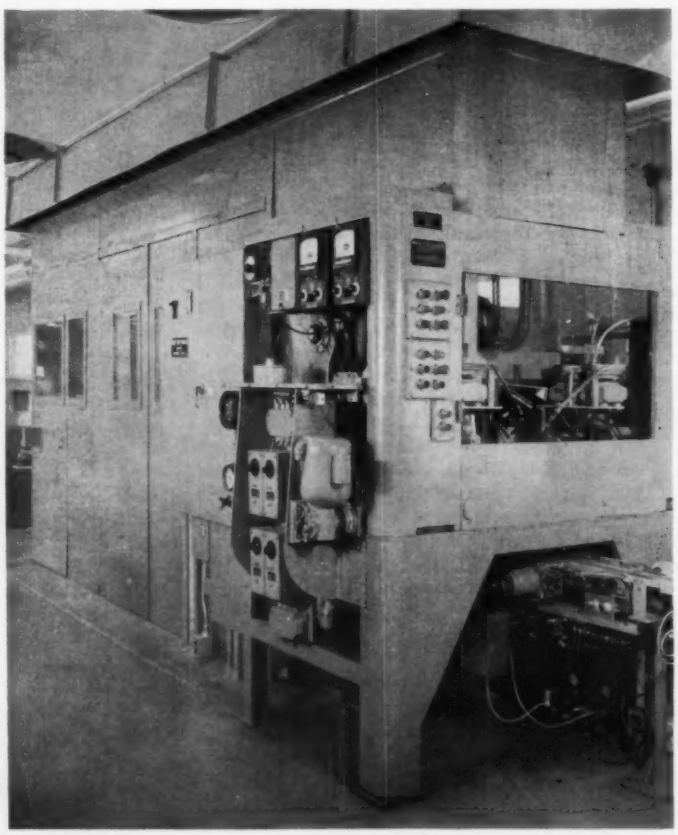
6

After helixing, the resistors are conveyed on pallets to the second inspection station. Feedback control and self-correction of the helixing machine are based on computer controlled analysis of resistance values measured at this station. Defective resistors are automatically rejected, and a strip chart recorder visually records the value of all resistors tested. Below the operator's hand can be seen the pallet conveying system for the resistors. The pallets transport individual resistors to each machine operating position and receive the resistors after the completion of the operation. A rubber-tipped push rod at each station is cammed upward, through the pallet, loading the resistor into the station. The resistor is held on the push rod by means of a vacuum operating through the center of the rod.

machine where gold-plated brass caps with wire leads are pressed on each end of a core. The capping machine uses two different capping assembly heads to apply three different cap assemblies for the four resistor wattage sizes. The computer controls both the switching of the assembly heads and the changing of the capping assembly sizes.

The components are then transported to a helixing machine which cuts a helical groove into the carbon film of the core to obtain the desired resistance. A computer-controlled bridge monitors the cutting operation as it is accomplished by rotating a chucked resistor against a diamond-impregnated wheel. The control servos of the bridge balance when the desired resistance is reached, disengaging the bridge lathe. The helix lathe bridge is slightly biased to compensate for machine inertia and for resistance change caused by heat generated in grinding. This data is programmed and stored in the computer memory drum. The computer also is connected into a servo that controls the speed and pitch used for proper spiralling.

The feedback control and self-correction of the helix lathe bridge is based on a statistical quality control analysis of values when the resistors are inspected at the second inspection station, immediately following the helixing machine. A Wheatstone bridge, set to the desired nominal resistance value of



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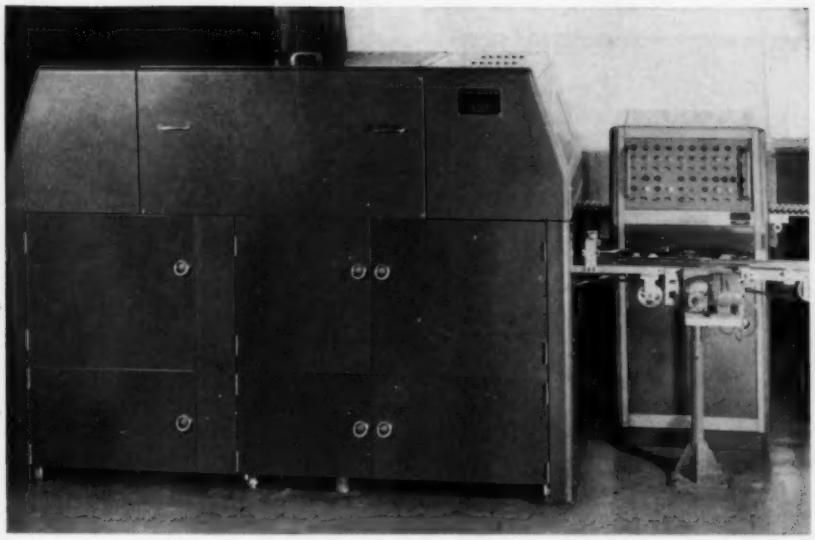
The next operation in the line occurs at the encapsulating machine shown. Resistors are fed from pallets into the machine and an epoxy shell is fitted over the core. After epoxy pellets are inserted over the wire leads of the resistor, pushed into the open ends of the epoxy shell, and held in place by resilient rubber chucks, the assembly is conveyed through an oven for approximately 15 minutes in a curing temperature of over 300F. The resilient chucks prevent entrapped air escapement in order to eliminate blow hole pressure leaks in the finished resistor seal. In the oven, the shell, fully precured, does not melt, and rests on the gold caps of the resistor, retaining an air space along the helixed body to prevent organic contamination of the carbon film. The partially cured pellets do soften when heated, forming an effective seal with the shell. After curing, the resistors pass through cooling water jets which terminate the cure of the pellets. Detection circuits within the machine reject any resistors with missing shells or missing pellets.



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Encapsulated resistors are checked for imperviousness of the plastic shell by this leak detection machine. The resistors are picked up from the pallet push rod by a holding clip of a leak inspection turret. The holding clip immerses the resistor in a hot water bath containing a wetting agent which prevents surface bubbles from clinging to the resistor body. The heat expands the air inside the capsule, and a series of 10 photoelectric cells detect air bubbles escaping from the resistors. A mechanical memory tab associated with each resistor holding clip is tripped when the cells detect bubbles. This tab retains the identity of the bad resistor and causes the component to be rejected at it leaves the testing tank. The machine can detect air leaks as small as 2×10^{-6} cc/sec.

each resistor lot by the computer, precisely measures the resistance of each resistor. Off-balance voltage is digitized and fed back to the computer, which then computes the desired correction and corrects the helixing machine setting.

The resistor next feeds into an encapsulating machine where a precured epoxy shell is fitted over the core and two partially cured epoxy pellets are inserted over each lead wire. After heating, curing, and cooling the encapsulated resistor is transported through a leak detection machine which detects small holes or cracks in the shell. Acceptable resistors are conveyed to a computer-controlled marking machine where the wattage, resistance value, production lot number, and date are stamped on the encapsulated resistor. Servo drives, controlled by the computer, can set any of 45 different code numbers with over a million and a half permutations of code and resistance value combinations. When the line switches over to a different size core, different lot, or different resistance value being processed, the computer automatically resets the marking wheels to the correct values.

After marking, the resistor passes through a third inspection station which checks the resistance value and feeds the data back to the computer. The information is used by the computer to compensate for shifts in resistance value caused by the heat of en-

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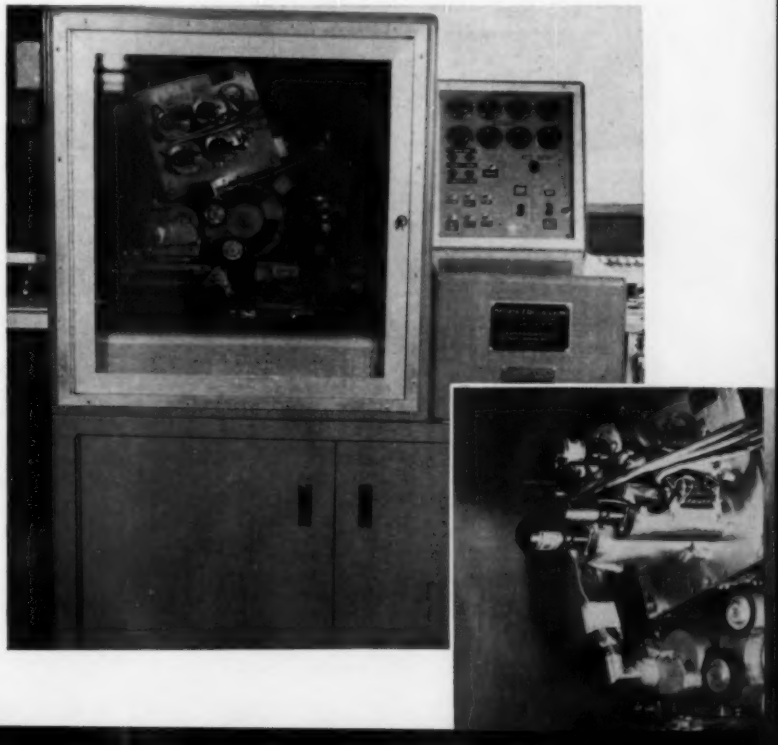
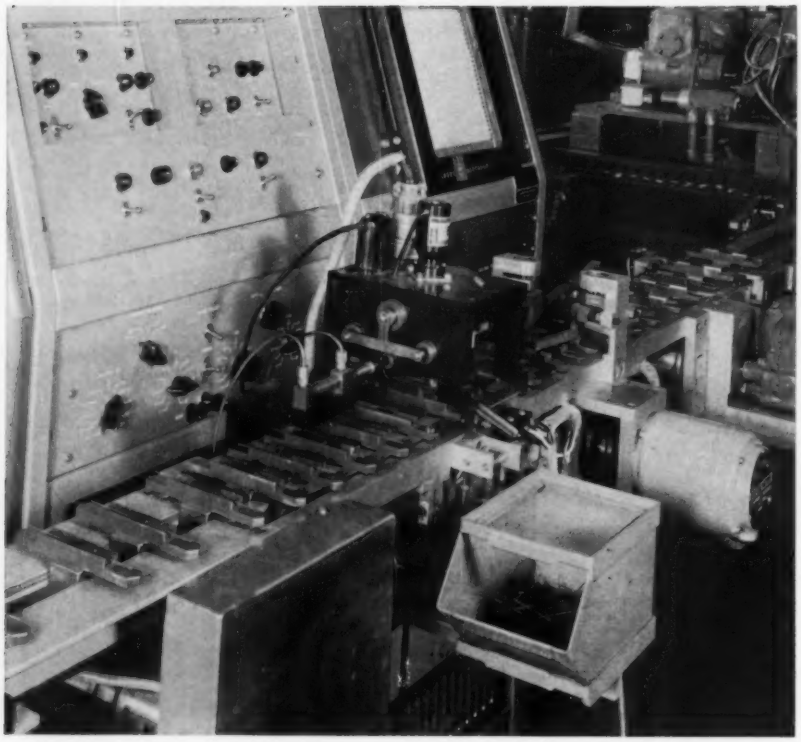
The accepted resistors are next conveyed on pallets to this automatic computer - controlled marking machine which stamps the wattage, resistance value, production lot number, and date on each component. The machine uses a modified offset printing technique. Conventional offset printing requires a small typehead which reciprocates during the inking cycle of the blanket roll. In this machine, the necessity for response to computer control dictated the use of a bulky typehead. Therefore, the blanket roll and inking rolls are mounted on a planetary gear arrangement. This permits the type head, inset, to remain stationary and allows the addition of servo drives to make the automatic type changing feature feasible. Automatic controls also provide blanket roll cleaning between code changes and during idle periods which might otherwise cause the ink impression to dry on the blanket roll.





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Closeup view shows the third inspection station of the system. This station checks the resistance of each resistor and feeds this data back to the computer. If the resistance value shifts due to the heat of encapsulation, the computer sends a corrective signal to the second inspection station. Again, as at other stations, bad resistors are rejected. Throughout the line, whenever a resistor is rejected, an additional core is added at the beginning of the line so that the exact number of resistors ordered are made by the line. This view also shows details of the pallet conveying system. Space is allowed between the machines for the accumulation of a five minute "bank" storage of resistors on pallets, and each machine feeds from this supply on a demand basis. Inventory control is maintained since each machine shuts down when its output storage space is filled.

capsulation. Corrected changes are then transmitted to the second inspection station and used to reset the computer-controlled bridge for the helixing machine.

Final station on the line is the packing machine where groups of resistors are inserted into foamed polystyrene blocks. This packaging method is a function of customer demand, and tape packaging may be substituted at a later date when justified by new requirements. The machine is controlled by the computer in that servos are actuated to control the stroke settings for the platen and anvil when the system is switched into processing different core sizes of resistors.

The accompanying photographs illustrate many of the mechanical details of the automated deposited carbon resistor production line.

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Final operation of the system is the packaging of groups of resistors into plastic blocks. When each pallet passes through the machine, its resistor is lifted off and pushed against succeeding resistors. When a certain number have accumulated, depending upon the over-all size of the resistors, the packing machine combs the wire ends straight and pushes the prepositioned resistors into a block. The block then moves down a hopper to a loading magazine. When a tray full of blocks has accumulated, a light illuminates, and an operator removes the finished components from the system.

AUTOMATIC BATCH WEIGHER IMPROVES REFRACTORIES PRODUCTION

By **J. C. WILLIAMS JR.**
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and

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REFRACTORIES production at Carborundum Co.'s Keasbey, N. J., plant has been significantly improved by the installation of an automatic batch weighing system, *Fig.* 1. Replacing a manual operation, the improved production system permits precise formulation and blending of various sizes of silicon-carbide grain to obtain optimal characteristics in specialized refractories.

In operation, silicon-carbide grain (from other Carborundum plants) is unloaded from hopper cars and transported to storage bins. From the bins, a bucket elevator lifts the grain to the top floor of the plant and dumps it into a surge bin. From this point, the material is fed onto two screens which automatically separate it into five different sizes. The sized material is gravity fed into holding bins.

When a batch is to be formulated, an operator sets weight verniers at a control panel for the amount called for in a batch formula. The batching and weighing cycle is started. The first holding bin automatically discharges grain into a weigh hopper, automatically shutting off the flow when the desired weight is obtained. Operating in turn, subsequent holding bins discharge material into the weigh hopper until the desired batch is obtained.

When the batch is complete, it is dumped into a standard receptacle for ease of transportation to other departments.

By means of a control panel the operator can monitor the operation at all times. In front of him are standard readout and control facilities. For example, panel lights indicate which holding bin is emptying at any moment; weights are indicated on a dial-type scale and recorded on a circular chart recorder.

As to improvements, the system is enclosed, reducing dust in the area to a minimum. Automatic operation precludes virtually all chances of human error, and batch rejection because of improper grain distribution has been eliminated. The weighing system built by Weighing & Controls Inc., maintains an accuracy of ±0.25 per cent of calibrated weight range, resulting in an improved quality in finished products.

The design of the pneumatic weighing system, *Fig.* 2, has also resulted in reduced maintenance costs. Another common problem—that of particle bridging at the mouth of hoppers—has been solved by use of vibrators. Holding bins have been provided with vibrators, and the weigh hopper has been designed as essentially two hoppers in one: A vibratory discharge unit and a weigh hopper.

Fig. 1—In silicon-carbide batching operation, operator can select desired weights for each of five different particle sizes. System automatically dump-weighs each particle size into weight hopper. When desired total batch weight is reached, particles are discharged into receptacles. Pneumatic weight transmitter is mounted in structure above operator's head.

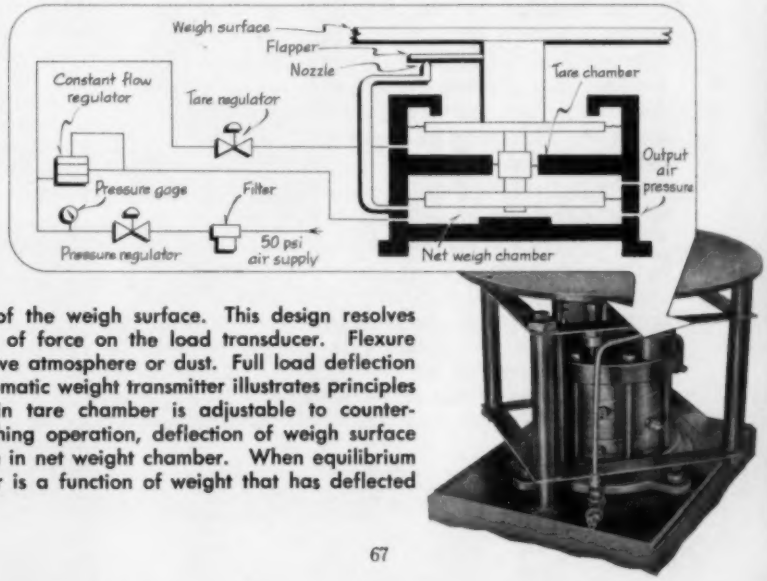

Fig. 2—System employs flexure mounting of the weigh surface. This design resolves all loads into a single vertical component of force on the load transducer. Flexure mounting method is not affected by corrosive atmosphere or dust. Full load deflection is on order of 0.005 inch. Diagram of pneumatic weight transmitter illustrates principles underlying weighing operation. Pressure in tare chamber is adjustable to counterbalance fixed weight of hopper. In weighing operation, deflection of weigh surface reduces nozzle opening, increasing pressure in net weight chamber. When equilibrium is reached, pressure in net weight chamber is a function of weight that has deflected the weigh surface.

SPECIAL TOOLS CAN BE VERSATILE

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AS EXEMPLIFIED by a "special" machine at Convair/Pomona, the building block concept of creating machine tools offers job-shop producers an opportunity to improve operations without sacrificing flexibility of equipment. The machine presently performs cutting operations on four different workpieces and can be rearranged to accommodate different parts when existing designs are obsolete or are affected by extensive design changes.

Except for eight access holes in one of the four workpieces, the building block, or "Universal", machine performs all operations formerly done on four special machines. In addition, several other holes are machined that used to be done on conventional machine tools using separate fixtures.

Particularly significant is the cost saving realized upon changeover of three of the parts (of the four parts, one had never been tooled) to the new machine. Direct labor requirements have been reduced by 83 per cent. Expressed in standard hours, machining of these three parts used to take 9.08 hours, including setup at every ten parts. Less than 1.51 standard hours are now required (also including setup at every 10 parts) to do equivalent machining operations. Where the former use of individual fixtures in conventional machines stood at 48 per cent efficiency, the new method exceeds 80 per cent. Also included is the additional benefit of increased worker efficiency. Significantly, 100 per cent of the capital acquirement portion of the Universal is comprised of standard units which can be reassembled into another physical combination when required.

The machine consists of a circular base that houses a geneva drive index table and a coolant system. Attached to the base are eight wing-angle brackets that support quill-type thrust units and dove-tail guided, multiple spindle drill heads. The thrust units are standard components manufactured by Drillunit Inc.

Electrical controls are also modular in that each of the eight thrust units has its own complement of control relays, starters, and pushbuttons for non-automatic operation. These control components are housed in individual enclosures and attached to their respective wing-angle bracket assemblies. A remotely located master panel interlocks all eight "slave panels", and contains automatic selective sequencing drum switches and related components.

The circuits allow dial-switch selection for each of the four series of machining operations required. To run a particular part, the operator positions the dial-pointer in one of four places. No other electrical adjustment is necessary.

Each of the four parts currently machined has its own holding fixture. Each fixture is separately attached to a common adapter-base which is permanently mounted on the top surface of the machine's 16-station dial index table. The fixtures locate by a common center plug and are radially positioned by a diamond locator. Clamping is achieved by three cylinder-actuated swing clamps and a hydraulic hand pump. Drill and ream bushings are mounted in castings that are secured to the toe of each drill head station's riser casting.

Cutting tools are all equipped with adapters, which reduce changeover time to a minimum. An extra set of tools is held in a tool control board for immediate use. The operator sets sharpened tools to correct depth at a bench while the machine is automatically operating. Cycle times for the four parts vary from 12 to 38 minutes, while setup times vary from 40 to 50 minutes.

Setup is simplified by the use of instruction tables. One is provided for each of the four parts assigned to the machine. Each table shows setup requirements at the machining heads.

The basic machine can be rearranged if different parts are to be handled. Control changes in machining operation for a workpiece of new design are readily accomplished by adding to or changing drum switches or rewiring the contacts of a relay in the main control panel. It is not necessary to change wiring in the slave panels or interwiring between slave panels and main control panel or between slave panel and slave panel. In short, considering a major revamping, machine conversion costs will be confined to disassembly and reassembly labor, addition of control circuit module components to the master panel, and tooling costs.

Universal drilling and boring machine created from building block components is illustrated. In operation, the 16-station table indexes through 16 positions in one 360-degree rotation. Thirty-two indexes are usually required for completion of one workpiece. The 8 machine heads positioned about the table are so connected electrically that simultaneous machining by preselected heads is possible (usually three or four at a time). Grouping of simultaneous head operations is preset into the machine.

*Subsequent to preparation of this article, Mr. Cunningham resigned from Convair. He has established a consulting firm specializing in manufacturing methods under the name of J. B. Cunningham & Associates, Pomona, Calif.

TRANSFERRING METHODS

One of the cornerstones of automatic operation is the transfer of work in process. Good design requires ability to transfer workpieces or material to subsequent workstations each time a machine cycles. Many mechanisms have been devised to accomplish this function. How these systems work and under what conditions each is best applied provides a basic study for those who specify and those who design automation equipment.

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PROBABLY the most widely known example of large-scale automatic manufacturing equipment is the transfer machine. Historically, its roots extend almost to the beginning of automation in the metalcutting field. The transfer machine is the mainstay of certain types of production.

Basically, the transfer machine is a combination of sequentially arranged, individual machine tools that are integrated with interlocked controls and a work transferring device. Although not applicable or feasible in every manufacturing endeavor, this highly developed type of production system contains features that might well solve production problems in other industries. For example, transfer of materials or workpieces between workstations is a common problem. Methods that perform this function in transfer machines, therefore, are of general interest.

This article is based on a paper presented at the "Fifth Conference on Manufacturing Automation" cosponsored by AUTOMATION, Purdue University, and the Manufacturing Engineering Council, April 1961.

Swinging Finger Mechanisms

Many types of transfer devices have been designed for these machines within the last 30 years. The foremost and most widely applied method in use today is the swinging finger bar, *Fig.* 1. This mechanism consists of a bar, nearly as long as the machine, that has a series of spacer fingers fastened to it. The

Fig. 1—Swinging finger bar mechanism is widely used in transfer machines to advance piece parts between workstations. During part dwell periods, bar is rotated to swing push fingers beneath piece parts so that entire bar assembly can be retracted. Fingers are rotated to their vertical positions before each advance stroke.

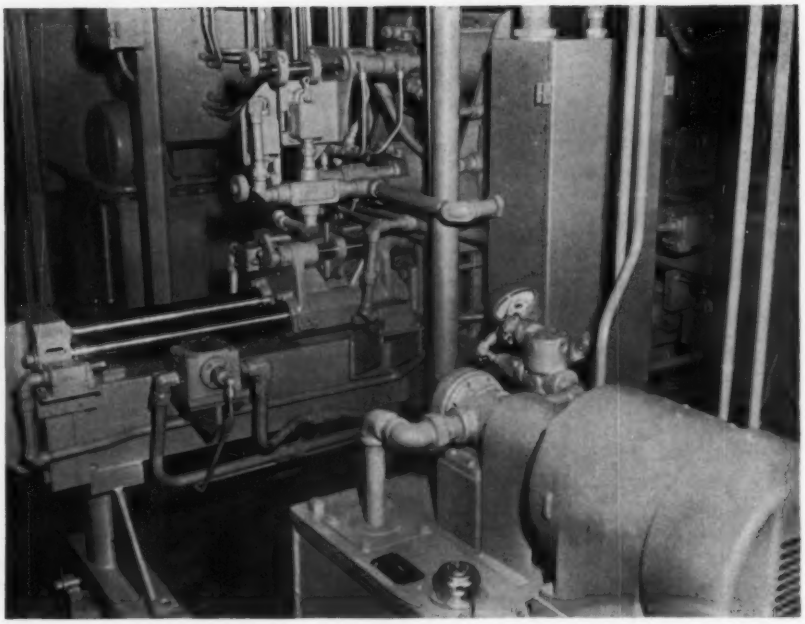


Fig. 2 — Close-up illustrates output end of standardized, single transfer bar actuating unit used to pull index pallets between workstations. Unit can be easily adapted to apply push forces for other transfer applications.

spacer fingers push the piece parts along from station to station. The mechanism is reset, or returned, by oscillating or swinging it away from the piece parts before retraction.

When properly designed, the swinging finger bar provides positive and relatively low-cost transferring. Generally the bar is supported and moves between the sides of a series of V-shaped or half round, stud-mounted rollers. The rollers are spaced so as to properly support the weight of the bar.

Bronze blocks, placed on top of the bar, retain this member. An alternative retaining method has been to use flat, stud-mounted rollers on top of the bar. However, during normal operation these rollers do not actually contact the bar nor do they rotate. Thus, they are considered ineffective in this respect by some designers. However, either rollers or bronze blocks will provide upper surface retention in the event of wreck-imposed loads that might otherwise lift the entire bar and damage the mechanism.

Another bar retaining method has been to use support bushings. These are split lengthwise so as to pass the transfer finger bases. However, this method is subject to easy contamination by chips.

As it is not usually practical to make a transfer bar in one piece, it is often jointed. The lengths of individual bar sections should then be based upon the ease of removal from the machine and fixtures. Servicing of the bar should be possible without the necessity of dismantling major machine units.

The design of transfer fingers requires careful proportioning. For example, the attachment to the bar must be strong, simple, and low in cost due to the number used. It must be remembered that a wrench or hammer dropped into the line of transfer, at a strategic moment, can cause the entire force of the transfer cylinder to bear on one piece part and one transfer finger. Rugged design can avert damage and thus prevent loss of production.

Wherever possible, particularly when pushing heavier parts at high transfer rates, the backs of transfer fingers should contact the leading edges of parts. This helps avoid skidding and controls positioning of the parts so that fixture locating pins can enter the part's locating holes. Undue wear of the locating pins is also prevented where parts are positioned positively. Process men and product designers can help machine vendors in this respect by providing castings with controlled or machined lengths at points where the transfer fingers contact the piece parts.

Transfer points on piece parts should be kept as close to the sliding plane of transfer as possible. This minimizes the force required and lessens transfer surface wear. Suitable cast or machined surfaces on the sides of parts should be selected or provided to allow proper side guidance by fixed rails in fixtures and idle stations. Generally, these surfaces should be at least twice as long as the parts are wide to achieve jam-proof guidance.

Many designs have been evolved to swing and propel or retract the transfer bar assembly. Generally, these motions are powered by standard hydraulic cylinders. The actual mechanisms used vary from vendor to vendor. The user need only concern himself that the device is rugged, serviceable, and free from undue wear and the entrance of chips.

▶ Standard Power Package

A standard transfer bar power package developed by National Automatic Tool Co., is shown partially in *Fig.* 2. The saddle, or cross head, is supported on

two guide bars and carries the swing cylinder. Bar way wipers prevent chip and dirt contamination of the bushings. The transfer cylinder in this rear view of a pallet machine is located to the right, under the last station in the machine. This is the station that discharges the pallet to the pallet return conveyor (not shown). The open type construction underneath this station is quite adequate for transfer cylinder maintenance and is accessible from the front of the machine. The cross head is shown in a position ready to pull parts for transfer index. A deceleration valve mounted to the transfer base is operated by a cam on the cross head.

This unit allows coupling of the transfer bar to either end of the cross head by reversing the swing shaft. Also, the transfer cylinder may be assembled to either end of the cross head. Such versatility permits mounting the assembly to a transfer machine in the most suitable position. A similar two-bar, standardized unit is available for handling wider parts.

▶ Lift and Carry Unit

Another widely used transfer device is the lift and carry type shown in *Fig.* 3. It is generally used to convey aluminum and other soft, non-ferrous parts which would be subject to too much wear if slid along rails. The lift and carry mechanism is also called the walking ladder or walking beam device by some suppliers. Essentially, it involves the use of one or two rails nearly as long as the machine, that ride on rollers beneath the piece parts. The rollers are mounted to lifting levers. A hydraulic cylinder first raises the entire ladder device and all the piece parts by swinging the lift levers upward in unison. Then the ladder is propelled through the transfer stroke by another hydraulic cylinder or a mechanical drive. At the completion of the transfer stroke the swing levers lower the ladder, placing the parts in their next stations. The ladder bars are then reset, or returned to the starting position, during the part clamping and rapid traverse portions of the cycle.

This system has advantages in that it allows the use of accurate, fixed locating-pin type fixtures when desired and, by eliminating skidding, avoids wear of piece parts. It also allows transfer of piece parts where part contour does not permit proper side guidance for conventional transfer, as parts can be nested in the transfer device.

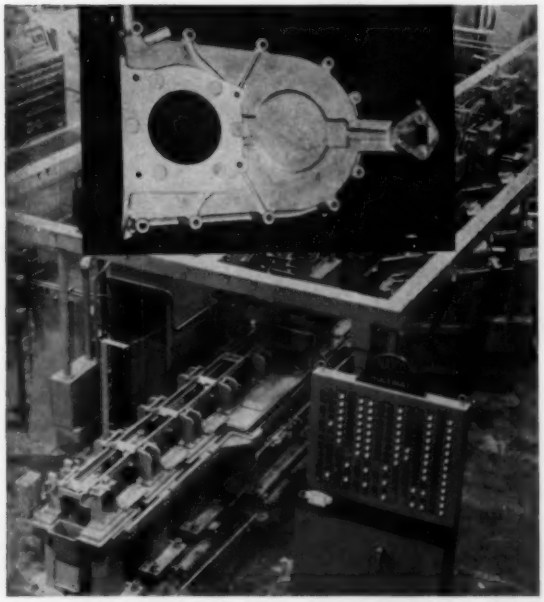


Fig. 3—Lift and carry type transfer device employs two rails that lift piece parts from below. Raised assembly is then transported lengthwise on rollers a distance equal to one index motion. Assembly then lowers, depositing piece parts in stations. Fully lowered assembly is retracted to starting position to complete transfer cycle. Device is useful in handling soft, nonferrous parts where sliding is undesirable.

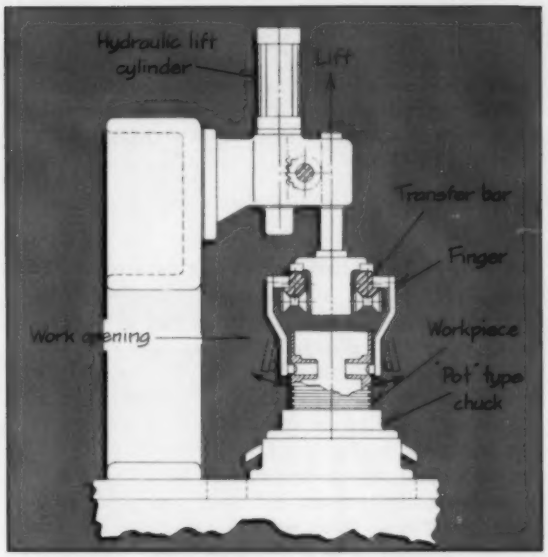


Fig. 4—Overhead grab and carry method is used in this transfer mechanism. Principle is useful where parts are soft and easily marked or where holding fixtures would interfere with transfer mechanisms mounted below level of parts.

▶ Overhead Mounted Devices

A deviation of the lift and carry principle is found in the overhead grab and carry method, *Fig.* 4. This mechanism has been used with success for piece parts that are soft and easily marked as well as those with small areas where it is impossible to use the lift and carry system mounted underneath the parts without interference of the transfer bar with the holding fixtures.

The system includes two overhead bars, each with a series of fingers which enter holes in the

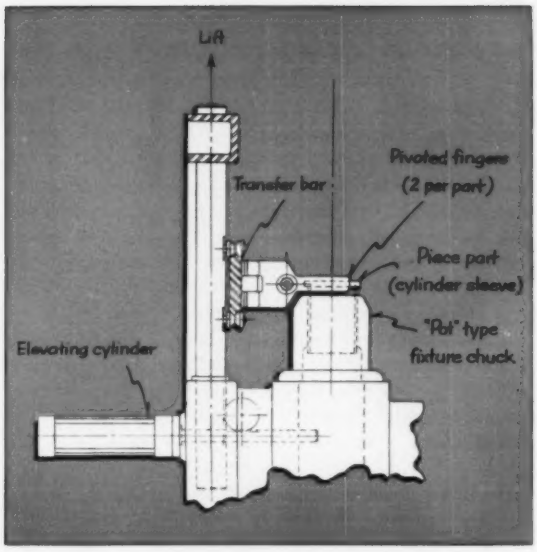


Fig. 5—Variation of lift and carry transfer mechanism provides transfer of cylindrical parts between chucking devices. System employs a single transfer bar carrying a series of clamping devices that grip tops of parts between fingers.

parts when the fingers are swung into place. The entire bar assembly and parts are then raised to a point of sufficient clearance by means of overhead racks and pinion plungers working in unison. The bars are propelled forward for transferring and then lowered to complete the index.

Another variation of the basic lift and carry design is shown in *Fig.* 5. This device employs only one bar upon which are mounted a series of air or mechanically actuated chucking devices for round parts. In general, these methods are more expensive and are utilized only where conditions make them mandatory.

Parallelogram Transfer Method

A lift and carry version that can be called a "parallelogram transfer method" is diagramed in *Fig.* 6. This assembly consists of four bars in the form of an upper and lower bar on each side of the machine. Each upper bar is supported by a series of links attached to a lower bar. The angular movement of the links is restricted by stop pins in the lower bars. The lower bars are propelled longitudinally by hydraulic cylinder through a stroke that is greater than the index stroke so as to provide overtravel on both ends. A transfer cycle begins with the upper bars in their lowest positions. As the lower bars are pulled backward a distance equal to the overtravel at one end of the stroke, the upper bars are held in place longitudinally by a fixed stop. This causes the lift links to raise the upper bars, picking up parts to a clearance position. After the links swing to the end of their restricted stroke and are slightly beyond their vertical positions, the entire assembly and the piece parts are indexed forward.

At the end of the forward index stroke the upper bars contact another fixed stop and the lower bars continue through their overtravel. This causes the lift links to pivot and carry the upper bars back to their lowest positions. The upper bars thus deposit the parts onto rest racks and continue downward to their clearance positions. The entire assembly is reversed in motion and reset to the beginning point of the index cycle. As this method can be installed beneath the piece parts, it is particularly suited for parts such as crankshafts, camshafts, and drive and axle tubes that require machining and accessibility to the ends of the parts.

Latch Finger Bars

Another common transfer method uses a latch finger bar design, *Fig.* 7. This is a relatively inexpensive transferring device. A single transfer bar, either round or rectangular in cross section, has a series of pivoted fingers mounted upon it. These fingers are either spring loaded or weighted so as to latch against the rear surfaces of the parts. Thus, a forward stroke of the bar transfers the parts. The

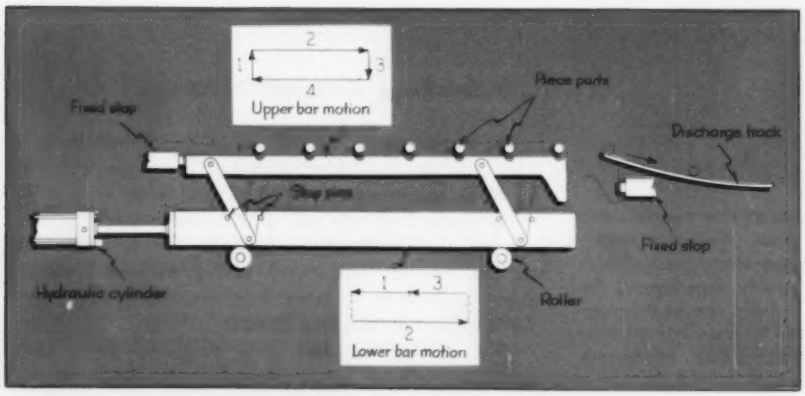


Fig. 6—Upper and lower pairs of bars are connected by links in parallelogram transfer mechanism illustrated. Links pivot to raise and lower bars; longitudinal motion is provided by hydraulic cylinder. Vector diagrams show motions of upper and lower bars during transfer cycle.

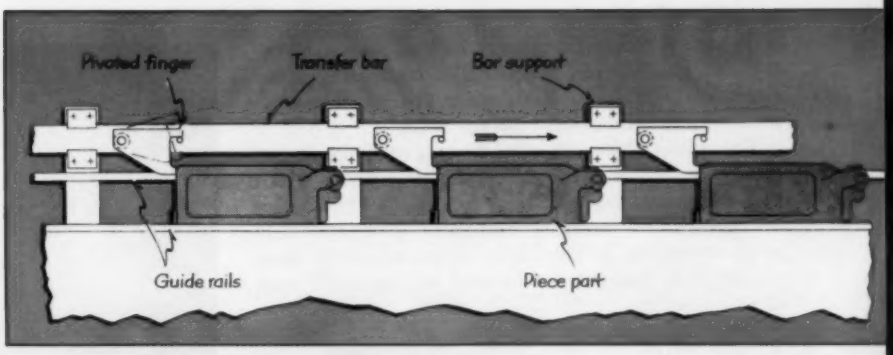


Fig. 7—A single transfer bar moves a series of latch fingers that engage rear surfaces of parts during advance stroke of this transfer mechanism. Latch fingers pivot upward and slide over parts during return stroke. Some finger designs include provisions to also engage front surfaces of parts.

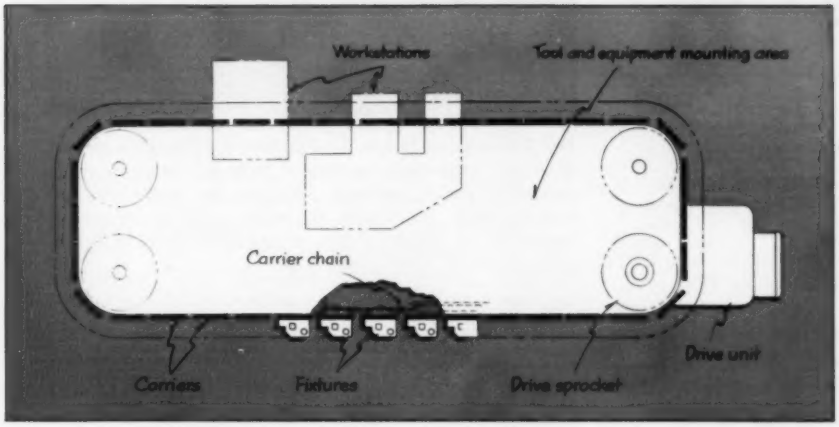


Fig. 8—Sprocket and chain drives can be used to transfer fixtures and piece parts where weights involved permit light chain tensions and do not introduce chain stretching problems. Method can also be used for pallet return systems where machine control actions are based on pallet positions and timing is independent of chain stretch.

fingers pivot upward and slide along the tops of the parts during the return stroke.

The main disadvantage of this system is that transfer rates are limited in order to avoid excessive skidding of the parts when the bar is stopped at the end of the forward transfer stroke. To help solve this problem, some finger designs include an angle on the back so as to retain the forward ends of the piece parts. Such designs have met with varying degrees of success. They have been particularly helpful in devices that transfer parts between machines and for other transfer conveyors where the absence of chips, coolant, and oil avoids contamination of finger pivot points.

▶ Sprocket and Chain Systems

A system that is often thought of, but seldom used in the metalcutting machine tool field, is the sprocket and chain drive. The greatest objection to the use of this design is the factor of stretch of the chain and the resultant loss of control of piece part or pallet position. This method has been used with good success in machines intended to convey parts to various stations for subassembly, inspection, gaging, and light machining, *Fig.* 8. Here, the fixtures and piece parts are light enough so that drag and chain tension are at a minimum and chain stretch is practically nonexistent. The sprocket and chain method has been used with good success in pallet return systems where the machine controls are arranged to work from the pallets as they are delivered at the end of each leg of the system. These controls are electrically interlocked with other functions of the machine. Because timing is external, chain stretch is not critical.

▶ Positioning Accuracy

An important criterion in the selection of transferring and fixturing methods is the accuracy requirement. General usage in transfer machines has proved the practicability and precision of the disappearing, or retractable, locating-pin fixture design. Use of one round and one diamond-shaped pin entering into precision machined dowel or manufacturing holes in the parts can provide position repeatability of ±0.002 to 0.003 inch. This accuracy is based upon ±0.001-inch location of a 0.001-inch diameter toleranced master or round pin hole in the part and ±0.0005-inch location of the pin in the fixture. Allowing ±0.0005-inch alignment of machine components to the fixture pins, and including the normal drift of cutting tools, hole placement can be maintained within ±0.003 to 0.005 inch. Use of fixed locating pins could improve the accuracy of part positioning by 0.0005 inch.

Piece parts having two or more holes requiring close inter-relationship to one another warrant special consideration. It is best, in this instance, to process so that all closely related holes are finished in one station to avoid index relocation inaccuracies.

Pallet type machines are inherently more accurate than moving part machines. This is due to the use

of hardened locating bushings and consistent placement of locating pin holes. Pallet positioning accuracies of ±0.001 to 0.002 inch are possible with proper design and careful workmanship.

The pallet shown in *Fig.* 9 was bored to an accuracy of ±0.00025 inch. This, coupled with 0.0005-inch toleranced holes in bushings and a 0.0002-inch concentricity of bushing diameters, gave extremely accurate results. Reamed holes in parts held in these pallets were consistently located within 0.002 inch of true position.

▶ Other Considerations

Consideration should be given the placement of equipment. Indexing, rotating, or swinging cylinders should be mounted to allow for complete, fast removal for service. What maintenance man wants to dismantle half of an idle station and remove an entire fixture just to replace a piston rod packing in an index cylinder?

Indexing bars should be mounted above the parts, if operations allow, to keep them out of the chips. The round bar and V-shaped support roller design will work well under piece parts and in the line of chip flow. However, this design should be used only when operations from the top and both sides dictate that they must be so placed.

Limit switches and deceleration and directional control valves should be accessible with a minimum of effort. Sometimes additional floor space is required to provide this accessibility. When planning a line or a building which includes transfer equipment, such provisions are well worthwhile. It is desirable, to ensure consistent production, that transfer mechanism controls allow manual indexing both forward and in reverse. It is equally important that manual pushbuttons give control of each portion of the total motion. Nothing in transfer machine operation is more disconcerting than having a jamup of parts and bars and no means such as a jogging provision to relieve the jam. Console panels should contain indicator lights to show completion of transfer stroke motions during either automatic or manually controlled cycling.

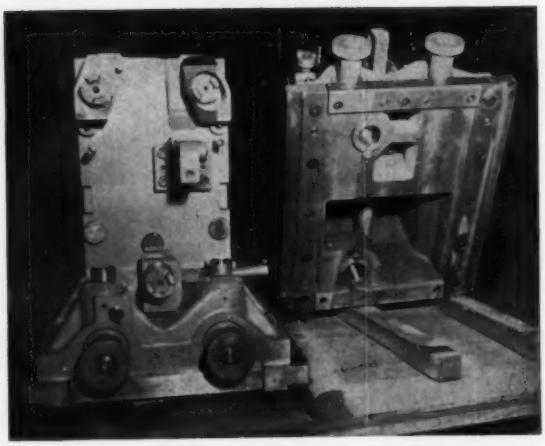


Fig. 9—Close-up of identical pallets in different positions illustrates important features. Reamed holes in parts placed in pallet structure, left, can be consistently located within 0.002-inch of true position. View of underside of pallet, right, shows shot bolt bushings, slide surfaces, and guide rails.

Hydraulic components must receive complete and proper consideration. Cylinder size must be carefully selected to provide ample thrust to overcome total part inertia and sliding friction. Hydraulic pumps must supply ample volume to ensure planned rapidity of motion. Valves and line sizes must be properly proportioned with respect to required oil flows to prevent undue pressure losses and allow rapid acceleration. Sumps must be of sufficient size to avoid overheating of hydraulic oil. Planned, adjustable control must be available for deceleration of parts and mechanisms. While adjustable, integral cylinder cushions may be adequate for a short transfer machine or for light piece parts, deceleration valves have been found to be best for heavy parts and long machines. Adequate time must be provided for deceleration and acceleration of the total load within the transfer cycle.

THE AUTHOR

M. CALVIN IRISH, chief product engineer, National Automatic Tool Co., is well qualified to discuss transferring methods by virtue of a broad background of experience in the design of packaging machinery, special automatic production machines, and transfer machines.

Prior to joining Natco in 1960 he was assistant chief engineer, Machinery Div., Ex-Cell-O Corp. Irish joined Ex-Cell-O in 1937 and was first assigned duties in the engineering design departments of the firm's Pure Pak and Machinery Divisions. In 1946 he left the company as machinery design checker to become a sales engineer for E. E. Wood Machinery Co. He later rejoined Ex-Cell-O as a contact man to vendors of special machine design. Other positions with the company included supervisor of the Special Machine Proposal Dept. and chief engineer of Robbins Engineering Co., an Ex-Cell-O subsidiary.

Irish received formal training in mechanical engineering from Wayne University. He has also taken university courses in machine tool hydraulics, industrial electronic control, and operations research. Professional affiliations include membership in the ASTME and the Industrial Management Club of Wayne County.

SEPARATION METHOD PRODUCES CLEAN COAL

ONE OF THE main technical advances that has helped the anthracite (hard coal) industry compete more favorably with other fuels is the development of a heavy media or "float-and-sink" method of separating coal from waste. This method of separation takes advantage of the fact that some materials will float, while others will sink, when suspended in water whose specific gravity has been changed by adding ground magnetite. For example, when anthracite is deposited in a slurry of about 1.70 specific gravity, the coal floats off the top, and the heavier refuse sinks to the bottom.

Heavy media separation accomplishes three objectives that are very important to a mine operator. First, the method results in coal of uniform quality; second, it increases the rate of production; and third, it results in substantial savings in manpower.

An operating heavy media separation system has been installed at the Underkoffler Coal Service Co. at Lykens, Pa., by the Wilmot Engineering Co. This system is interlocked to a series of valves and electronic controls which automatically add magnetite when needed and rigidly maintain the specific gravity of the water-magnetite medium within plus or minus 0.003. Ash content of coal is held at a consistently uniform level, and low-ash coal that was previously discarded as waste is now recovered.

In operation, raw coal is trucked to the plant from small independent mines and fed to a reciprocating table which throws out large rocks and timber. The raw coal is then crushed to stove size, about 2 7/16 inches, and fed to a 4 by 10-foot Hewitt-Robins Inc. Eliptex vibrating screen, having two perforated plate decks. The top deck of the screen has 1-inch openings, and the bottom deck has ¼-inch holes.

Streams of water are sprayed on the screen to wet the coal and prepare it for entry into a Wilmot heavy media vessel. Pieces of coal larger than ¼ inch feed from the two decks to the heavy media vessel while the smaller fines are fed to a fine coal plant. In the heavy media vessel the coal floats on the surface of the medium and is collected for delivery to a dewatering screen. The refuse sinks to the bottom of the vessel. Both products—coal and refuse—are then fed to a 5 by 16-foot Hewitt-Robins dewatering screen which is partitioned lengthwise, allowing the cleaned coal and refuse to move in separate paths and discharge into separate chutes.

The processed coal is then elevated to sizing shakers which sort it into the several sizes in which it is sold. From the shakers, the different sizes of coal are dumped into bins to await shipment to customers in the Northeastern states and Eastern Canada.

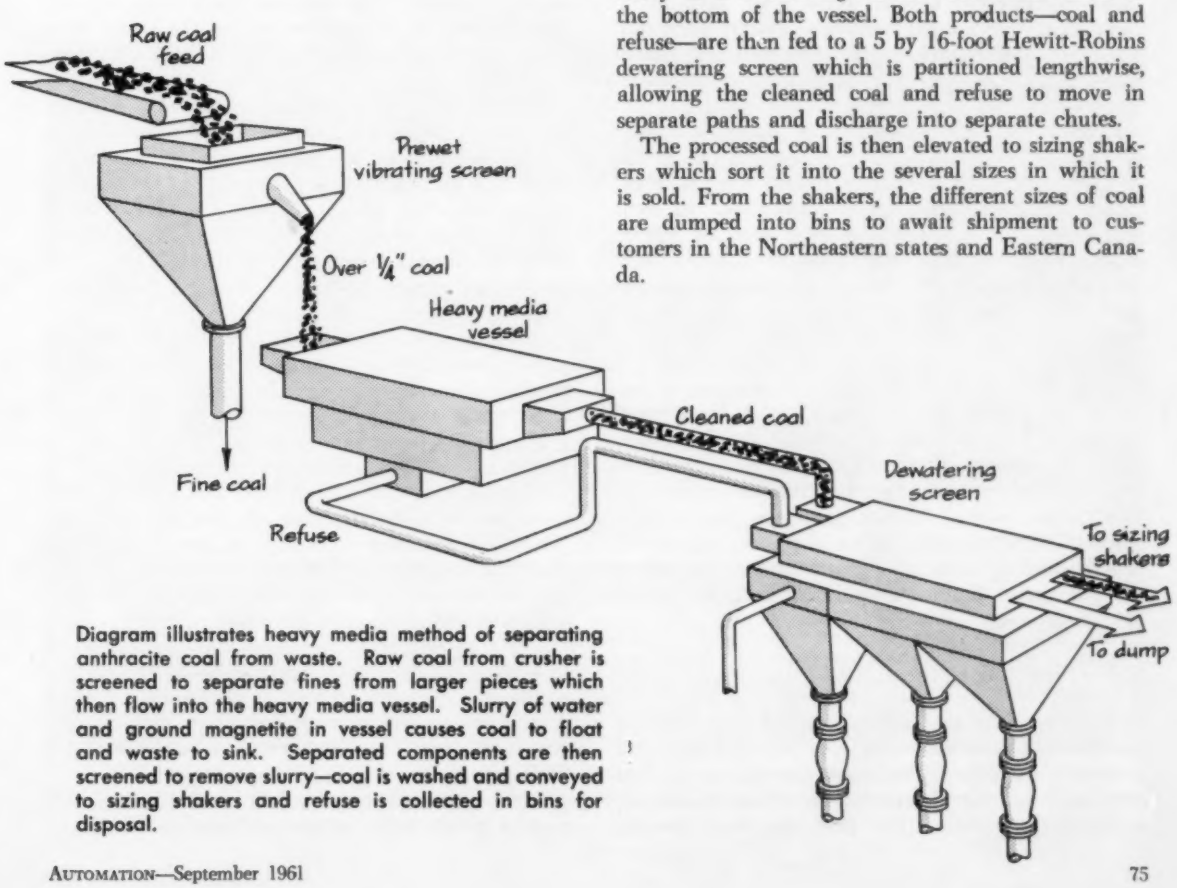


Diagram illustrates heavy media method of separating anthracite coal from waste. Raw coal from crusher is screened to separate fines from larger pieces which then flow into the heavy media vessel. Slurry of water and ground magnetite in vessel causes coal to float and waste to sink. Separated components are then screened to remove slurry—coal is washed and conveyed to sizing shakers and refuse is collected in bins for disposal.

SYSTEM ASPECTS OF CONTROL COMPUTER APPLICATION

An important ingredient in the successful application of computers is an appreciation of the possible functions which can be performed. Reporting, supervising, and controlling are three major functions in process applications. The author also identifies degrees of complexity within the major functional classifications.

By **R. O. DECKER,** Advanced Systems Engineering and Analytical Dept. Westinghouse Electric Corp., East Pittsburgh, Pa.

SUCCESSFUL application of a digital control computer to achieve automation of an industrial process requires an intelligent system engineering approach. System engineering can be defined as the economic and scientific co-ordination of production machines, digital computers, related input-output devices, transducers, and instrumentation. System engineering is usually performed by a team because plant operating methods, equipment performance, operator capabilities, control techniques, and many economic factors must be considered in applying a computer to automate a plant or process.

The team must include engineers who have detailed knowledge about plant operations. In some instances, this knowledge can be supplied by industry engineers from the computer manufacturer; in many instances, the knowledge must be supplemented by the customer's engineers, who become full or part-time members of the system engineering team.

Also, the team must include engineers who understand the limitations and capabilities of the plant equipment and its control, including the necessary instrumentation and transducers to couple the computer to the process. The plant equipment may include steam boilers, turbines, generators, motors, rolling mill stands, or other types of process equipment. The control equipment may include such devices as valve actuators, motor starters, and feedback controls.

The Study

The first step in a system study is to determine the feasibility of achieving specified technical and economic objectives. In many instances, this first step includes the determination of technical and economic objectives. The first step must provide answers to two questions: 1. Can computer control be applied to the process? 2. Can the computer and other instrumentation be justified economically?

The second step is to undertake a detailed study of the process, including a study of pertinent technical literature. This detailed study leads into the development of a mathematical model based upon equations describing energy and materials balances and other process characteristics. Many relationships involved in the development of the mathematical model are empirical and must be obtained from a large amount of accurately collected plant data. In almost all applications the stability of the control scheme must be proved. Stability can be proved either analytically or (in the case of more complicated systems) experimentally. The experimental studies are performed on a simulated model, usually on an analog computer.

If the control scheme is feasible and inherently stable, the next step is to establish required instrumentation and convert the control scheme into a sequence of logical operations that can be programmed into a digital computer. This sequence of computer logical operations is represented by flow charts. The system analyst who charts the problem need not be familiar with all the intricate programming details of the computer, but needs a general understanding of its capabilities. In general, the flow charts for a given problem are the same regardless of the computer used.

The translation of information in the flow charts to a sequence of instructions is done by skilled programmers. This magnitude of programming effort in an average computer application is great and the cost and time requirement of programming and "debugging" should not be overlooked.

Often the experimental data available from the process is not sufficient to establish exact relation-

ships between variables. In this event, the computer can be used to accumulate and correlate data from the process after a computer is installed. After sufficient data has been accumulated, improvements can be made in the control program and the computer can go into closed-loop operation.

Remaining steps in a system engineering approach include such factors as training personnel in programming and maintenance, installation, and open loop testing. During open-loop testing, all computer programs are checked; that is, the computer accepts signals from the plant's instruments and processes the signals, but the computer outputs are recorded, not fed to the subloop control elements. As the programs are being checked out, the mathematical model can be improved on the basis of accumulated data. The final step is to close the loop for automatic control by the computer.

The preceding steps are common to many computer control applications, although each application has different characteristics. In some applications the system operation and relationships between variables are well defined, and therefore, the design of a control scheme is relatively simple. In others, great preliminary study effort must be devoted to defining the relationships between variables. Some applications are of the simple sequencing type while others use fast dynamic control. The success of any computer-control application depends on the system engineer's knowledge of the system, his familiarity with what a digital computer can do, and, to a measure, his ability to recognize similarities and differences between applications.

▶ Computer Capabilities

A digital control computer can perform one function, or several, and determining exactly what is needed for a particular process or plant is a critical step. A digital control computer, its relation to a process, and the three major types of functions performed in the system are shown in *Fig.* 1. The inputs to the computer are measurements of physical input variables, measurement of plant or process parameters, measurements of certain physical disturbances, and measurements of physical output variables.

The three major functions are categorized by the nature of the action taken by the process control computer. If the output is in the form of typed or printed records to be examined at some later date, the computer performs a reporting function. If the output is in the form of signals to the operator, the computer performs a supervising function. If the output is in the form of signals transmitted to control the process, the computer performs a control function. These functions are diagrammed in *Fig.* 2.

In the reporting function, the computer presents tabulated information ranging from raw data to complex process engineering data. Raw data presenta-

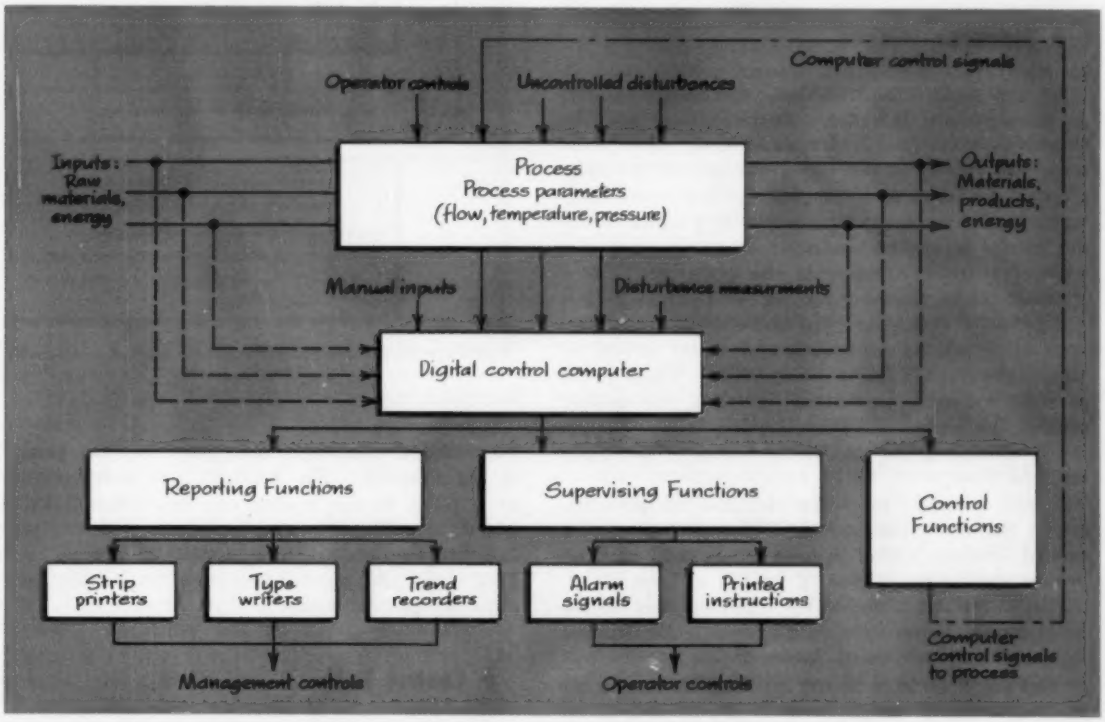
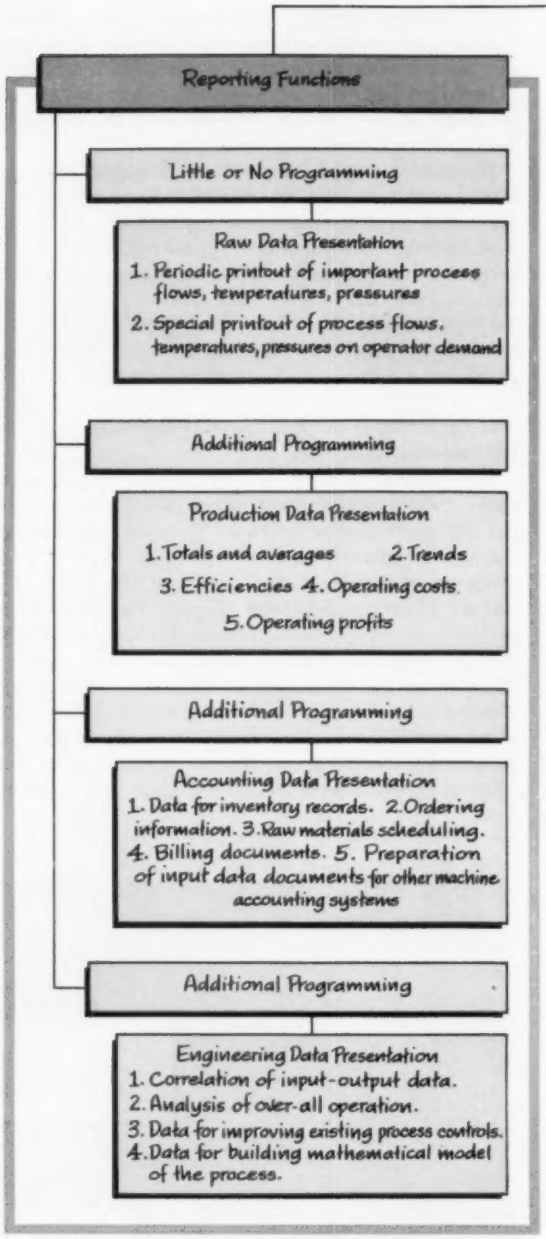


Fig. 1—Generalized diagram shows how computer is related to major elements in a system. The broad area which must be studied in detail suggests that a team approach is best in preparing a system study.

tion includes periodic printout of process flows, temperatures, and pressures. Also, special printout on operator demand is provided. Little or no programming is required for this operation. By additional programming, the raw data can be "smoothed" and calculations performed to present production data. This includes totals, trends, efficiencies, operating costs, and operating profits.

Accounting data presentation includes facts for inventory records, ordering information, raw materials scheduling, the preparation of billing documents, and preparation of input data documents for other machine accounting systems. The presentation of engineering data includes correlation of input-output information, analysis of over-all operation, and data for improving existing process control and for building a mathematical model of the process.

Examples of these functions can be found in various steel and electric utility applications. In one automatic steam plant, efficiencies will be calculated every fifteen minutes and a warning signal will be given to the operator if efficiencies are below specified limits. In a computer-controlled tinning line, calculations of incentive pay are made from production data. In this same application, a shipping ticket which includes quality classification is prepared by the computer for each coil as it is produced. An example of analysis of over-all operation is found in the electric utility industry where heat rate calculations are made, giving the power output per ton of fuel input.


Reporting Functions
Little or No Programming
Raw Data Presentation
1. Periodic printout of important process flows, temperatures, pressures
2. Special printout of process flows, temperatures, pressures on operator demand
Additional Programming
Production Data Presentation
1. Totals and averages 2. Trends
3. Efficiencies 4. Operating costs
5. Operating profits
Additional Programming
Accounting Data Presentation
1. Data for inventory records. 2. Ordering information. 3. Raw materials scheduling. 4. Billing documents. 5. Preparation of input data documents for other machine accounting systems
Additional Programming
Engineering Data Presentation
1. Correlation of input-output data.
2. Analysis of over-all operation.
3. Data for improving existing process controls.
4. Data for building mathematical model of the process.

▶ Supervisory Role

In the supervising function, the computer acts as an important link between the process and the process operator. In the supervising mode, the computer rapidly scans input voltages representing physical variables and compares each scanned voltage with the correct voltage stored as a digital number in the computer memory. In many cases, the scanned quantity represents the open and closed states of valves, the on or off condition of motors, etc.

The fact that a quantity is above or below a reference value can be recognized, and visual or audible alarms given when limits are exceeded. These limits may be imposed for reasons of safety, for quality control, for loss of efficiency, for low levels of product inventory, or for unsuitable values of the input material flow.

Special printout programs can also be initiated, giving the numerical values of the deviation from desired levels. Under certain conditions, such as process equipment failure, a history of events preceding the failure is desirable. The computer can be programmed to preserve readings on a logarithmic scale over the previous ten hours.

A great advantage of the stored-program digital computer over a simple data logger-scanner is its capabilities when an abnormality is encountered; here the computer can be programmed to enter an analysis mode of operation, in which it examines the surrounding conditions and prints out an analysis of the situation. For example, a high temperature at a point in the system can be indicated by an alarm; in addition to simple alarming, the computer can be programmed to interrupt its normal scanning cycle and scan temperatures and pressures of adjacent process areas.

▶ Control Role

The control functions of a process control computer are the most advanced operations, although the sequencing control operation is relatively simple.

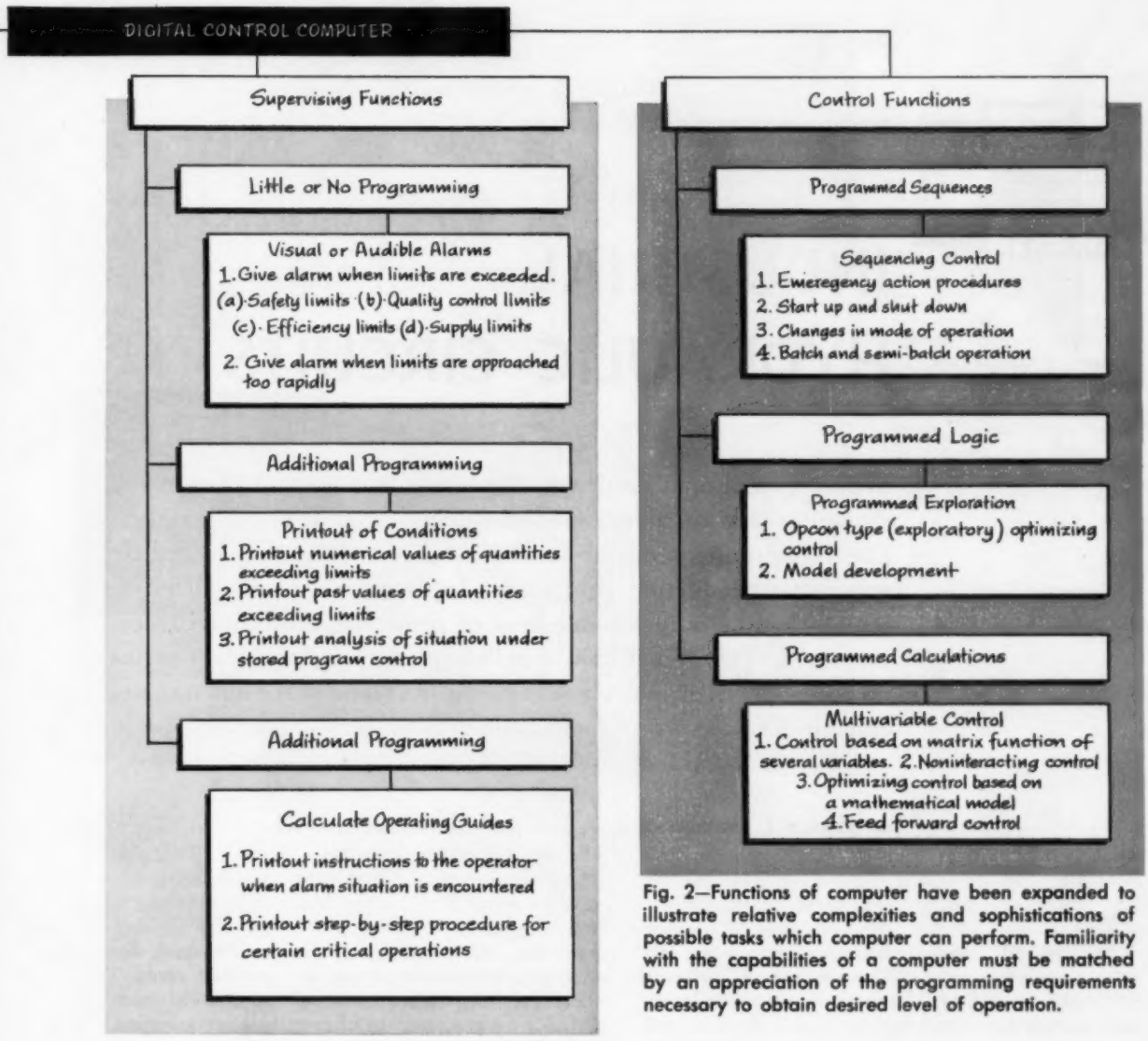

DIGITAL CONTROL COMPUTER
Supervising Functions
Little or No Programming
Visual or Audible Alarms
1. Give alarm when limits are exceeded.
(a) Safety limits (b) Quality control limits
(c) Efficiency limits (d) Supply limits
2. Give alarm when limits are approached too rapidly
Additional Programming
Printout of Conditions
1. Printout numerical values of quantities exceeding limits
2. Printout past values of quantities exceeding limits
3. Printout analysis of situation under stored program control
Additional Programming
Calculate Operating Guides
1. Printout instructions to the operator when alarm situation is encountered
2. Printout step-by-step procedure for certain critical operations
Control Functions
Programmed Sequences
Sequencing Control
1. Emergency action procedures
2. Start up and shut down
3. Changes in mode of operation
4. Batch and semi-batch operation
Programmed Logic
Programmed Exploration
1. Opcon type (exploratory) optimizing control
2. Model development
Programmed Calculations
Multivariable Control
1. Control based on matrix function of several variables. 2. Noninteracting control
3. Optimizing control based on a mathematical model
4. Feed forward control

Fig. 2—Functions of computer have been expanded to illustrate relative complexities and sophistications of possible tasks which computer can perform. Familiarity with the capabilities of a computer must be matched by an appreciation of the programming requirements necessary to obtain desired level of operation.

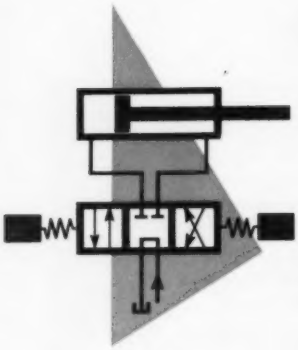
Sequencing control involves logical decisions in carrying out emergency actions, in starting up and shutting down a process, or in changing the mode of operation of a process. Sequencing control has been applied in the steel industry to control the sequenced operation of a rolling mill. In the electric utility industry the starting and stopping procedures of turbine generator operation are examples of sequencing control.

Programmed exploration involves the changing of controlled process inputs in discrete steps and recording the resultant changes in the process outputs. This type of exploration can be used for two purposes: To carry out an experimental type of optimizing control, or to develop a mathematical model of the process.

Multivariable control is a level of control beyond that provided by single-loop analog controllers. For example, the controlled quantity may be represented by several output variables; the desired quality may not be measurable directly but may be a computed function of temperatures, pressures, densities, or other variables.

In non-interacting control, the interactions among several input and several output variables are greatly reduced or eliminated. For example, such a control might be designed so that a change in one input variable causes a change in several output variables. To change only one output variable and hold the others constant, additional input variables would have to be changed at the same time.

Optimizing control based on a mathematical model of the process involves the solution of equations to find a maximum or a minimum value. The mathematical model may be either linear or nonlinear. To date, such controls have been based on a steady-state model of the process. Feedforward control anticipates the effects of disturbances occurring "upstream" and makes adjustments to compensate for the effects of these disturbances.



Part 4

ELECTROHYDRAULIC SERVO SYSTEMS

INDUSTRIAL HYDRAULIC CIRCUITS

Where exceptional accuracy, flexibility, and control of machine dynamics are involved, manufacturing engineers are adopting electrohydraulic servo systems in the control portions of their automatic production equipment. In many instances, such systems offer the only feasible way of providing the required performance. This fourth and concluding part of a four-part series on industrial hydraulic circuits points out some of the advantages, capabilities, and uses of electrohydraulic servo systems.

By **DONALD E. BROKMEYER**, Electrohydraulic Servo Group, Vickers Inc., Detroit, Mich.

USE OF electrohydraulic servo systems on automatic production machinery is well established. Such systems have proved to be an ideal means for obtaining the highly flexible and precise control of motions required on modern machine tools and various other types of fabricating and processing equipment.

Most manufacturing engineers have a "speaking acquaintance" with servo systems, but many do not appreciate the high degree of control that such systems offer. In this concluding part of a four-part series on industrial hydraulic circuits, some of the characteristics, performance capabilities, and industrial applications of electrohydraulic servo systems will be reviewed.

Desirable Characteristics

Advantages obtainable with servo control are numerous, with flexibility, accuracy, and control of dynamics heading the list. With regard to flexibility, a servo system can handle a wide range of loads and cycle times, and can be programmed easily by the use of a command signal representing a desired result at the load. The program, being electrical in nature, can be changed readily. Any of the programming means now available can be used, including potentiometers, tape, and punched cards.

Accuracy of a desired end result (machine element position, velocity, etc.) is inherent in a servo system. This is especially true for a closed loop type servo system where variations in load, friction, temperature, and leakage can be automatically compensated for over a wide range of operating speeds and loads.

Control of system dynamics is one of the most important attributes of an industrial servo system, from the standpoints of both over-all performance and economics. With proper design and application of servo components, increased operating speeds with accurate control and stable operation can often be obtained. Other benefits that can result from use of electrohydraulic servo controls for production equipment include lower tooling costs, reduced setup times, improved part-to-part uniformity, and less rigid inspection requirements.

Servo Valve Operation

An electrohydraulic servo valve is essentially a directional flow control valve where the output flow is closely proportional to the magnitude of an electrical input signal applied to an integral torque

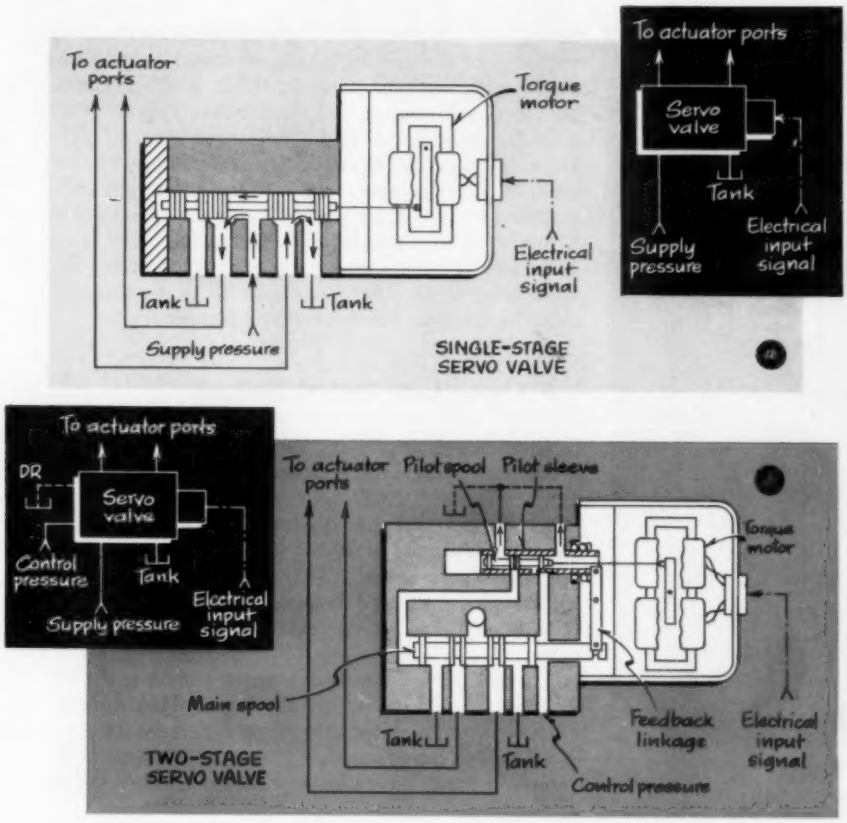


Fig. 30—Cutaway views illustrate major elements of single-stage *(a)* and two-stage *(b)* electrohydraulic servo valves. Units provide hydraulic output flows that are proportional to magnitudes of electrical input signals applied to their torque motors. Symbols accompanying drawings are those used to identify the valves in the circuit diagrams that follow.

motor. In a single stage servo valve, *Fig.* 30*a*, the armature of the torque motor is connected directly to one end of the valve spool. Such valves are suitable for relatively small flows (under 5 gpm) and low pressures (up to 1000 psi).

Most servo valves in use today are two-stage units. This design provides a valve with high resolution, or sensitivity to control changes. Reaction forces caused by large flows acting on the main spool of the valve do not affect the performance of a two-stage valve since the input signal is transmitted from the armature of the torque motor to a pilot stage.

A typical two-stage industrial servo valve is diagrammed in *Fig.* 30*b*. This unit incorporates sliding spools in both the pilot and main stages. Other commonly used two-stage servo valves incorporate a jet pipe or a flapper nozzle arrangement instead of a sliding spool in their pilot stages.

In operation of the valve, a signal from an amplifier is directed to the coils of a torque motor. When a differential current exists in the coils, an armature deflects and displaces the pilot spool. For example, if the pilot spool moves to the left, control fluid will flow to both ends of the main spool. Since the effective area of the lefthand end of the main spool is twice that of the righthand end (because of the presence of a rod on the righthand end of the spool), the same pressure acting on both of its ends will cause the main spool to shift to the right.

As the main spool moves to the right, a feedback linkage connecting the main spool and the sleeve for the pilot spool will also move. This will cause motion of the pilot sleeve to the left, which will eventually close the pilot control port leading to the lefthand end of the main spool. When this occurs, the main spool will remain in a certain position until a change in the differential current in the torque motor coils causes the pilot spool to assume another position.

If the pilot spool is moved to the right, the lefthand end of the main spool will be opened to drain and there will be pressure only on the righthand end of the main spool. Then, the main spool will move to the left until the feedback linkage causes the pilot sleeve to close off the pilot pressure port.

▶ Basic Servo Circuits

An analysis of several simplified circuits will help set the stage for later discussion of more sophisticated electrohydraulic servo systems. The circuit of *Fig.* 31*a* is that for a basic hydraulic system in which a solenoid operated directional control valve and a flow control valve are used to control the direction and speed of a cylinder. A check valve bypasses the flow control valve to permit rapid return of the cylinder.

To convert this circuit into an electrohydraulic servo system, it is only necessary to replace the sole-

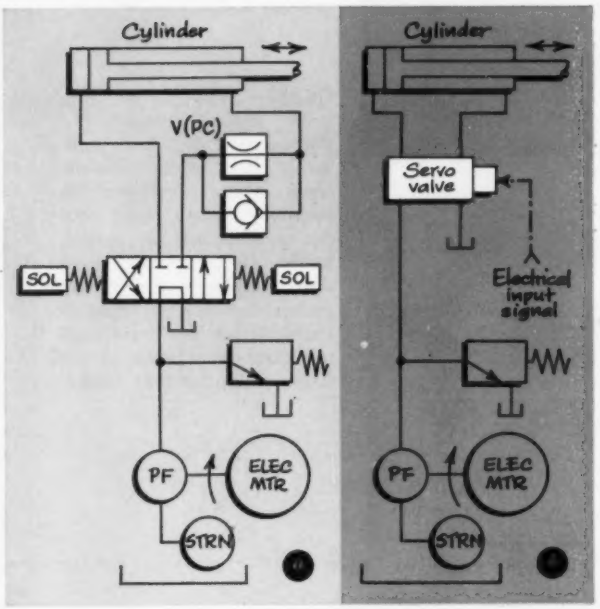


Fig. 31—Diagrams illustrate conversion of a conventional hydraulic circuit, *(a)*, to an electrohydraulic servo circuit, *(b)*, for controlling the speed and direction of a cylinder. In *(b)*, an electrohydraulic servo valve replaces the directional control valve, flow control valve, and check valve used in *(a)*. An electrical input signal to the servo valve determines the speed and direction of the cylinder.

noid operated directional control valve, the flow control valve, and the check valve in the basic circuit with a servo valve, *Fig.* 31*b*. An electrical input signal is provided to actuate the torque motor in the servo valve. This circuit is an open loop arrangement in that, while it controls cylinder direction and speed, there is no provision for continuously indicating the position or speed of the cylinder.

To overcome this disadvantage, most servo applications incorporate a feedback arrangement in which the output of the system is continuously monitored and compared with a reference input signal. This forms a closed loop system whereby the feedback device ensures that the programmed directions will be followed accurately. A basic closed loop, position control system using feedback is diagrammed in *Fig.* 32. In the circuit, a low level signal from a feedback potentiometer (representing actual cylinder position) is continuously compared with an input signal (representing a commanded cylinder position). Any difference between the two signals is increased to a usable level by an amplifier. The amplified difference, or error, signal then directs the servo valve to provide more or less oil to the actuator to make it attain the commanded position.

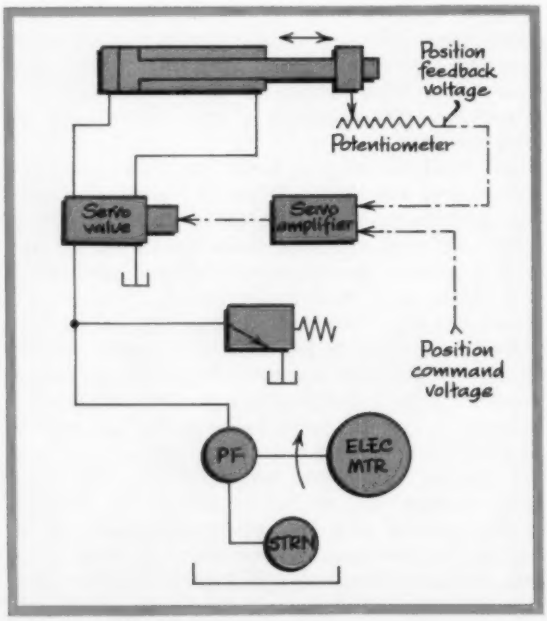
Fig. 32—A feedback potentiometer continuously monitors the actual position of a cylinder rod in this simplified closed loop servo system. The signal from the potentiometer, representing the actual position of the cylinder rod, is fed to an amplifier where it is compared with an input signal representing a commanded position. If the cylinder rod is not in the commanded position, an error signal will result. When amplified, the error signal adjusts the servo valve to move the piston rod to the desired position.

Closed Loop Control Methods

There are two primary methods of controlling a hydraulic circuit with a closed loop. The first, and most frequently used, is a valve-motor system in which a servo valve is used to throttle the flow of oil to a hydraulic actuator. The actuator may be a cylinder or a motor. This method of closed loop control provides rapid response and high accuracy. It is usually used where loads range up to 30 horsepower.

A typical closed loop valve-motor system is shown in *Fig.* 33. The servo valve is manifolded directly to the hydraulic motor so as to minimize the amount of oil under compression. This is a prerequisite to obtaining rapid, positive response to control signal inputs.

The nominal ⅓ pressure drop usually found in a servo valve leads to a certain amount of unavoidable horsepower loss or heat generation in a valve-motor system. Usually, the simplest and least expensive way of coping with this problem is to provide adequate heat dissipating facilities such as standard water or air coolers.



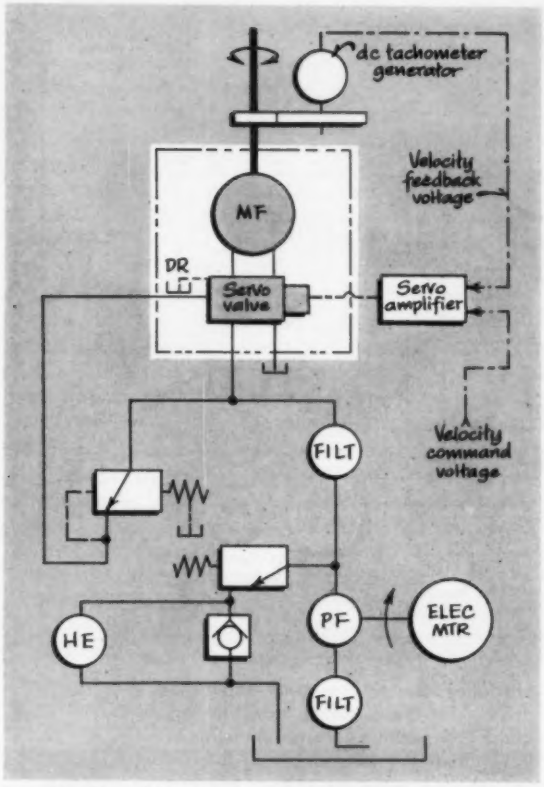


Fig. 33—Closed loop valve-motor system provides variable speed, reversible rotation of a fluid motor in response to electrical input commands. Velocity feedback is provided by dc tachometer generator coupled to motor output shaft.

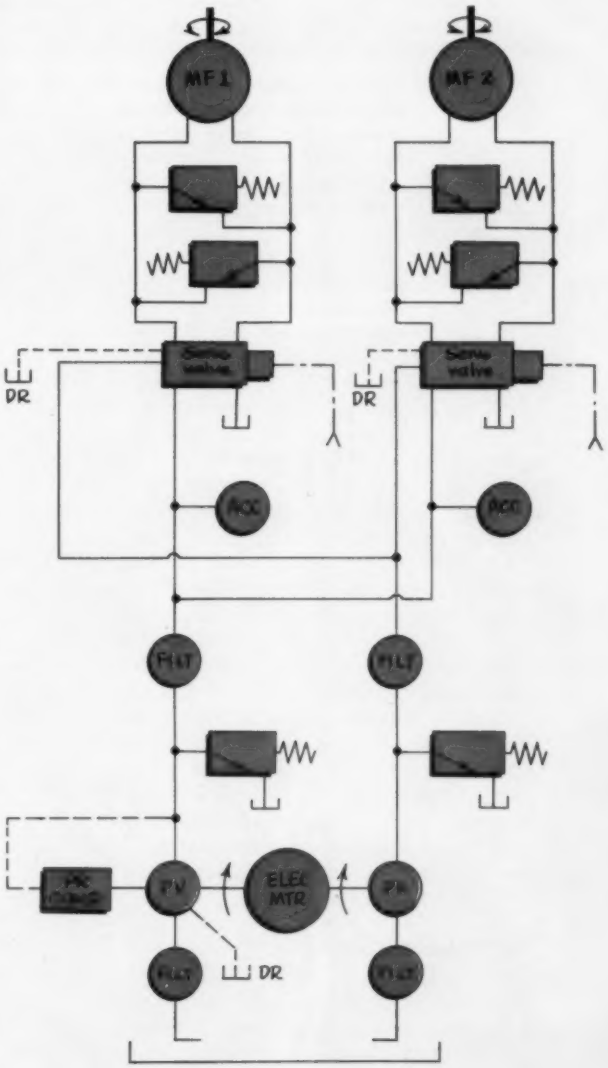
Temperature rise in a valve-motor system can also be controlled through use of a pressure compensated, variable delivery pump that provides only the flow necessary to maintain a preset pressure, *Fig.* 34. With this arrangement, when full flow is not required, the pump will be stroked back automatically to decrease delivery, thus creating less heat. As a result, it is often possible to omit supplementary cooling devices since the pump itself can easily dissipate the small quantities of heat generated. In circuits of this type, it is often desirable to use an accumulator near each servo valve in the system. The function of the accumulator is to provide oil on immediate demand and thus compensate for time lags in the delivery of fluid from the pressure compensated pump.

Fig. 34—Use of a pressure compensated, variable delivery pump in a valve-motor servo system minimizes heat generation since pump supplies only the amount of flow necessary to maintain a preset pressure. Accumulators in circuit provide oil on immediate demand to servo valves and thus compensate for time lags in response of pressure compensated pump. Fixed delivery pump supplies control pressure to servo valves.

Heating may also be controlled in a valve-motor system with an unloading circuit that bypasses excess flow to tank. In this type of circuit, pressure differential between the loaded and unloaded conditions must be kept as narrow as possible since it is undesirable to have a wide pressure differential at the inlet port of the servo valve.

The second primary method of closed loop servo control employs a servo valve to position a control cylinder on a variable delivery pump, *Fig.* 35. With such a servo pump arrangement, the output of the pump is controlled by the position of its yoke as determined by the position of the control cylinder. Positioning of the control cylinder is effected by the servo valve. The servo pump system is generally used for high flow and horsepower applications (above approximately 30 gpm and 30 hp).

An advantage of a servo pump system when compared with some valve-motor systems is the higher efficiency of the servo pump system from a heat loss standpoint. The pump in this arrange-



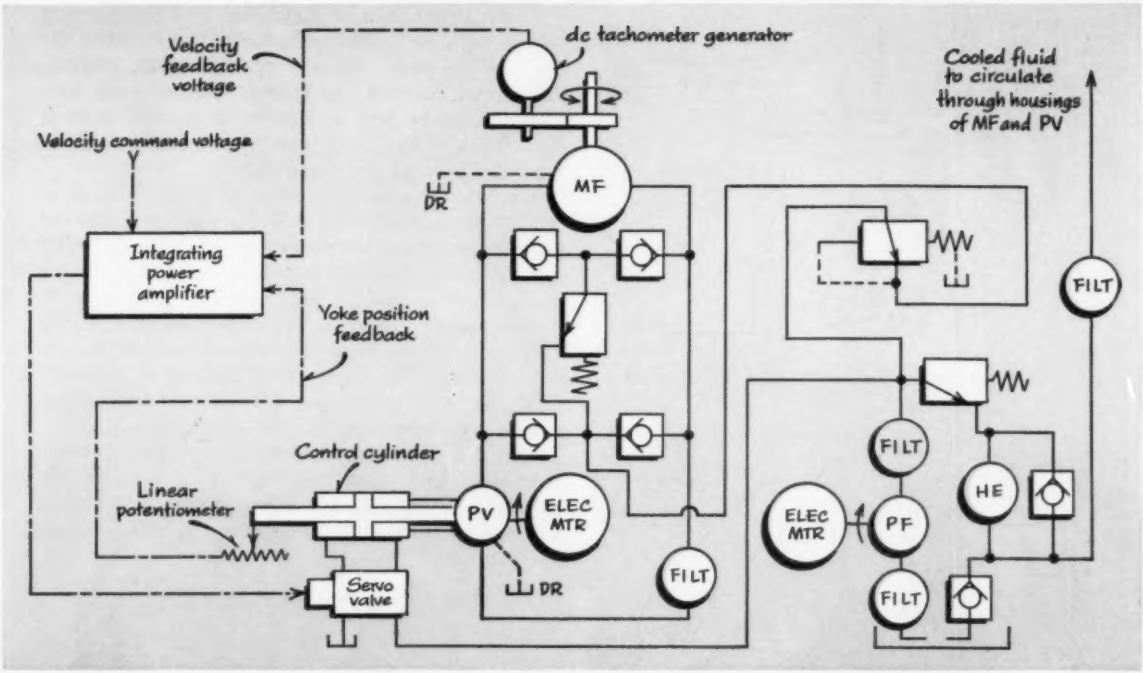


Fig. 35—Servo pump circuit provides high efficiency due to low heat generation in this reversible, adjustable speed hydraulic drive. However, system may be less responsive than valve-motor arrangement because of relatively large amount of oil under compression between pump and motor. Speed is regulated by feedback from dc tachometer generator. Linear potentiometer senses position of control cylinder for variable displacement pump.

ment provides only the amount of flow that is required by the load. A disadvantage of the system is that response may be slower because of the relatively large volume of oil kept under compression between the pump and the actuated motor or cylinder. The response problem with a servo pump system can be minimized, however, by keeping the hydraulic lines between the pump and actuator as short as possible.

In a closed loop system, one of the most important areas for consideration is the method of sensing the output functions. For example, velocity can be sensed with ac or dc tachometers used as feedback transducers. These units provide output voltages proportional to rpm.

Mechanical positions can be readily converted into electrical signals by a number of standard components. The most common position feedback devices used in electrohydraulic systems are: Rotary potentiometers, linear motion potentiometers, synchros, linear variable differential transformers, and rotary and linear motion inductive pick-ups.

▶ Velocity Control

Good accuracy in velocity control applications can be obtained with standard servo components and relatively simple closed loop systems. The servo drive system developed for a hydraulic pump test stand, *Fig.* 36, illustrates this point.

Performance test requirements call for running test pumps at various speeds and pressures. One of the requirements of the test stand drive system is that speed must not change with variations in pressure during a test. With the closed loop system, when one of these two variables is changed, the other automatically remains at its previous setting. For added control flexibility, preset potentiometers with pushbutton controls are provided for selection of slow speed, sweep speed, and high speed.

In operation, a fixed displacement hydraulic motor drives a test pump through a gear box, providing test speeds up to 4000 rpm. The servo valve in the circuit is used as a three-connection valve directly controlling the standard cylinder control of a variable volume piston pump. A tachometer generator driven by the hydraulic motor provides velocity feedback to close the control loop. A solenoid operated directional control valve, in the circuit between the servo pump and the hydraulic motor, reverses the direction of rotation of the latter unit. A fixed displacement vane pump is used to supply control and main pressure for the servo valve. Control pressure is held at the proper level by a pressure reducing valve. Speed regulation and repeatability of settings are within approximately plus or minus 5 rpm, or 0.125 per cent at 4000 rpm.

▶ Position Control

An interesting servo control system is used to position working elements at predetermined x-y co-ordinates in a panel wiring machine, *Fig.* 37. The machine automatically wires panels that have terminals arranged in a grid pattern. In a typical cycle, one cylinder moves "A" and "B"-type tool assemblies in the x co-ordinate. Another cylinder moves the "A" tool and "A" dressing fingers (for removing insulation) in the y co-ordinate. The third cylinder moves the "B" tool and "B" dressing fingers in the y co-ordinate. A standard machine accepts 20 by 20-inch panels that have grid spacings of 0.20 inch.

As shown in the circuit diagram, each axis is positioned by an individual hydraulic cylinder controlled by a single-stage electrohydraulic servo valve. The position of each cylinder is sensed by a rotory potentiometer connected in a voltage divider circuit.

Input signals are obtained from a card reader, or programmer, which selects the correct voltage (representing position) through a resistor matrix. The error voltage is amplified by a two-stage dc servo amplifier and fed to the torque motor of the servo valve for the axis.

A small hydraulic power supply, located in the base of the machine, supplies fluid to the three cylinders simultaneously. The power package includes a 10-gallon reservoir and a variable delivery, pressure compensated vane pump. The pump is driven by an electric motor mounted on the side of the tank. A small accumulator is used to ensure availability of oil on instantaneous demand and to act as a buffer preventing interaction between the simultaneous motions.

Needle valves are used to meter fluid to the servo valves since the valves receive only positioning signals in this system. The needle valves limit the maximum table "slew rates" to 15 ips. Smooth acceleration and deceleration characteristics required for proper tension control of the wire being wrapped are obtained by adjusting the dc error signal levels.

An example of the positional accuracy and speed capabilities of a servo system is given by an application on a 30-ton numerically controlled turret punch press, *Fig.* 38. The machine is designed to handle a maximum material thickness of $\frac{1}{4}$ inch, with a maximum hole diameter of $4\frac{1}{2}$ inches. Sheet sizes range up to 48 x 96 inches. Traversing speeds up to 600 ipm and absolute hole accuracies of plus or minus 0.003 inch are obtained. In the high accu-

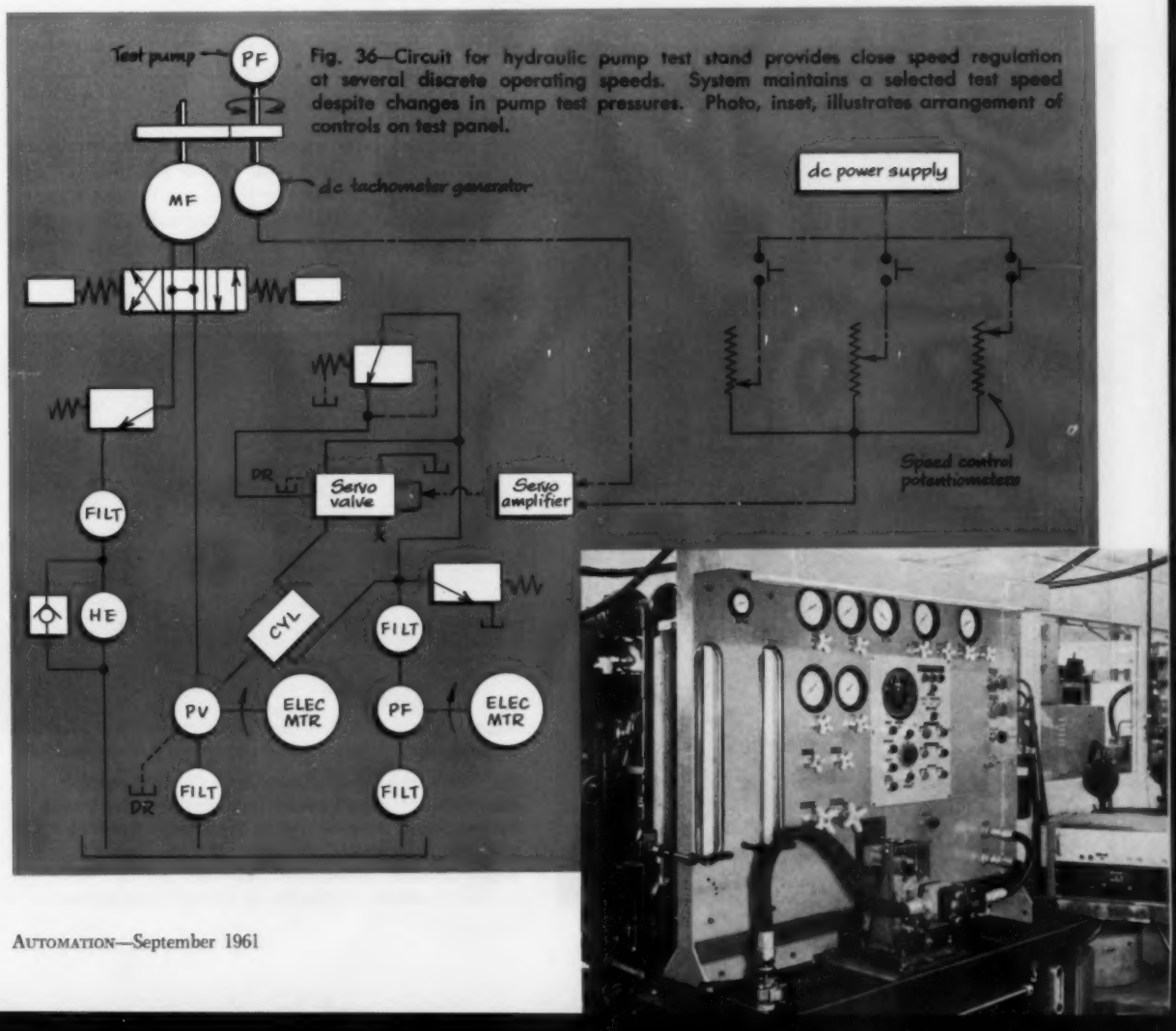
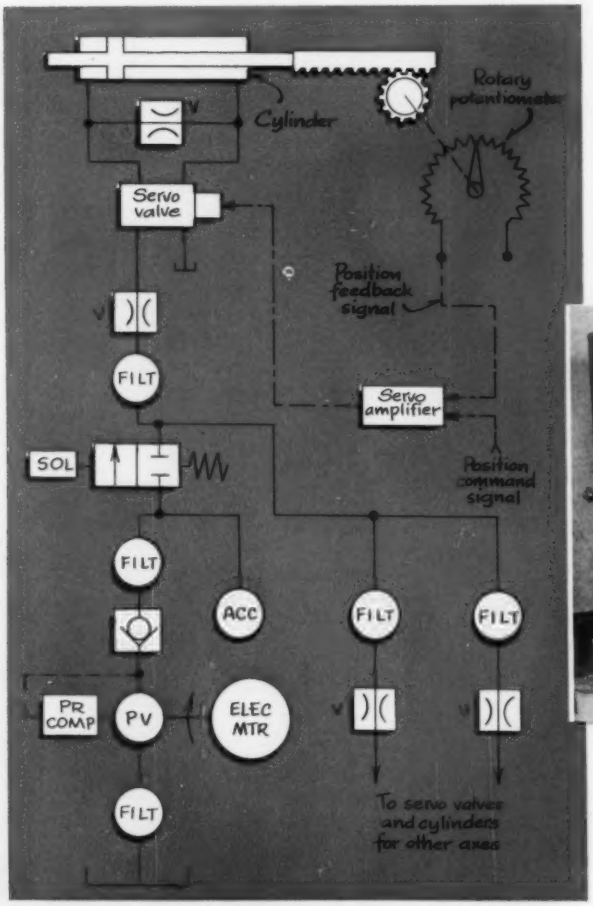


Fig. 36—Circuit for hydraulic pump test stand provides close speed regulation at several discrete operating speeds. System maintains a selected test speed despite changes in pump test pressures. Photo, inset, illustrates arrangement of controls on test panel.

racy mode of operation, a production rate of 60 hits per minute is obtained. Over 70 hits per minute are possible when the machine is programmed for positional accuracies of plus or minus 0.005 inch.

In-out and crosswise motions of the 4000-pound press table carriage are provided by two hydraulic cylinders with double ended rods. The rod ends are connected to stationary supports, while the cylinder bodies are attached to and drive the carriage. Each cylinder is hydraulically controlled by a two-stage servo valve with mechanical feedback. A pressure-compensated, variable volume pump and an accumulator are used to supply oil to the two hydraulic cylinders. Indexing of the turret is accomplished with a hydraulic motor controlled by a conventional four-connection, solenoid operated, directional control valve.

In a remote control application, *Fig.* 39, a closed loop positioning system is used to adjust the speed and pressure on the main ram of a 3000-ton forging press. This system gives the operator very rapid control of the position of a large steam valve on the press.



In operation, a command potentiometer is positioned manually by means of a lever. A feedback rotary potentiometer is mechanically coupled to the crankshaft of the main valve. Fluid for the main stage of a servo valve is supplied by a fixed displacement pump; a pressure reducing valve is connected to the main circuit to obtain oil for the first stage of the valve. A standard rack-mounted dc amplifier is used to increase the magnitude of error signals fed to the torque motor of the servo valve. In this particular application the servo system avoids the need for a cumbersome system of mechanical linkages.

Contouring Control

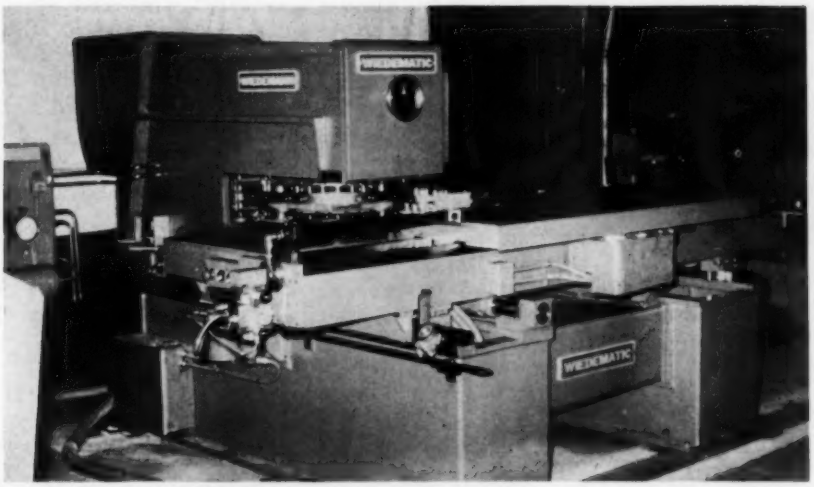
In the preceding applications, either velocity or positional information is used to control an electrohydraulic servo valve. Since a servo valve may be readily programmed with practically any combination of electrical commands by combining the velocity and positional information, the valve is readily used where the desired output function is a controlled path of movement as in contouring machines.

The electrohydraulic servo circuit for a five-axis general purpose milling and contouring machine is shown in *Fig.* 40. Each of the five axes is controlled simultaneously with a servo valve-motor package driving a ball lead screw through a gear reducer. Hydraulic motors with inherent high torque output, combined with small inertias in their rotating members, allow for exceptional dynamic control.

A punched tape supplies input command signals in small, finite increments. This information can be used either for point-to-point positioning or path control. Electrical transducers, mechanically coupled to the ball lead screws, transmit feedback signals

Courtesy, Gardner-Denver Co.

Fig. 37—Three servo controlled cylinders position tool assemblies at programmed rectangular co-ordinates in this automatic wire wrapping machine. Average cycle time for connecting one wire to two terminals on a 20 by 20-inch panel is 6 seconds. Complete circuit for one positioning cylinder is shown in diagram.



Courtesy, Wiedemann Machine Co.

Fig. 38—Numerically controlled turret punch press positions metal sheets under selected tools for piercing and stamping operations. Worktable that positions sheets is moved along two axes by electrohydraulic servo systems. Table traverse rates up to 600 ipm, and absolute hole accuracies of 0.003 inch, are obtainable.

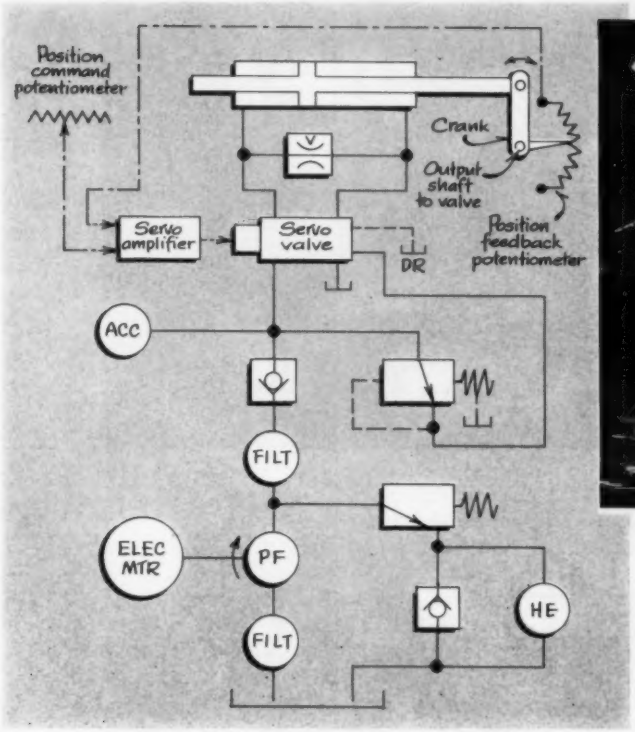
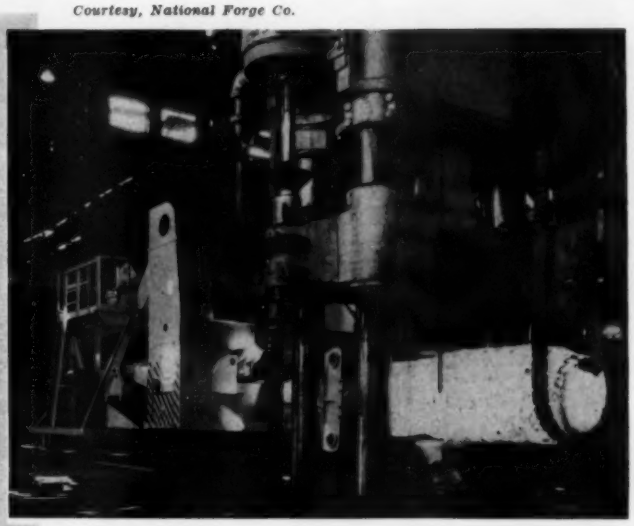


Fig. 39—Speed and pressure of the main ram on a 3000-ton forging press are controlled remotely by adjustment of a steam valve with the electrohydraulic servo circuit shown. Ease of control and operator safety are primary considerations.

Courtesy, National Forge Co.



that correspond to machine motions. Total absolute accuracy of this machine is approximately plus or minus 0.0005 inch per foot with an approximate repeatable accuracy of plus or minus 0.0003 inch.

The hydraulic power supply consists of a pressure compensated, variable volume piston pump which is supercharged by a low pressure, fixed displacement vane pump. A second fixed displacement pump furnishes control oil for the first stage of each servo valve.

▶ Web Speed and Tension Control

Equipment for processing continuous web materials such as paper, cardboard, foil, fabrics, film, and metal strip usually requires drives that can provide accurate control of web speed and tension. Availability of wide, stepless ranges of operating speeds and tensions in such equipment provides the flexibility necessary to maintain product quality at all production rates up to maximum.

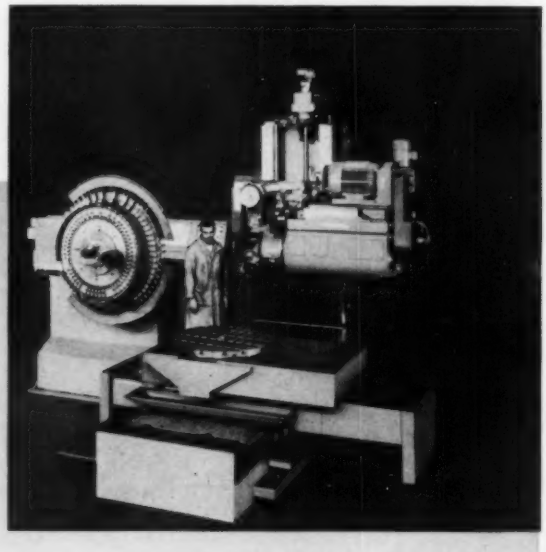
In a multistation laminating machine, web speed and tension are controlled automatically with a system that includes several integrated electrohydraulic drives. The machine produces a cardboard base web coated with a thin printed paper sheet. Control of web speed and tension in a typical section of

the machine is accomplished with the system illustrated in *Fig.* 41. In operation, incoming web speed is sensed by a dc reference tachometer generator, *TG*1. Signals generated by this component are impressed across a potentiometer, *P*1, whose output is fed to a servo amplifier. With no change in the setting of the potentiometer arm, the output voltage of *P*1 will reflect the speed of the web entering the section.

A second dc tachometer generator, *TG*2, provides signals indicating the speed of the web leaving the section. These signals are impressed across the terminals of potentiometer *P*2 feeding the servo amplifier. Under the foregoing conditions, if the signals indicating incoming and outgoing web speed are different in magnitude, an error signal will be developed by the servo amplifier. This error signal, when applied to the torque motor of a servo valve, will change the speed of a hydraulic motor driving the outgoing web. The speed change will be in the proper direction and amount to reduce the error signal to zero. In this manner, web speed control is effected.

Tension in the web is controlled with an air-cylinder loaded dancer roll that is linked mechanically to the arm of potentiometer *P*1. As the dancer roll changes position the arm of *P*1 will also move. This will modify the signal from reference tachometer generator *TG*1 and call for a change of speed of the hydraulic motor driving the outgoing web. The

Courtesy, Sundstrand Machine Tool Div., Sundstrand Corp.



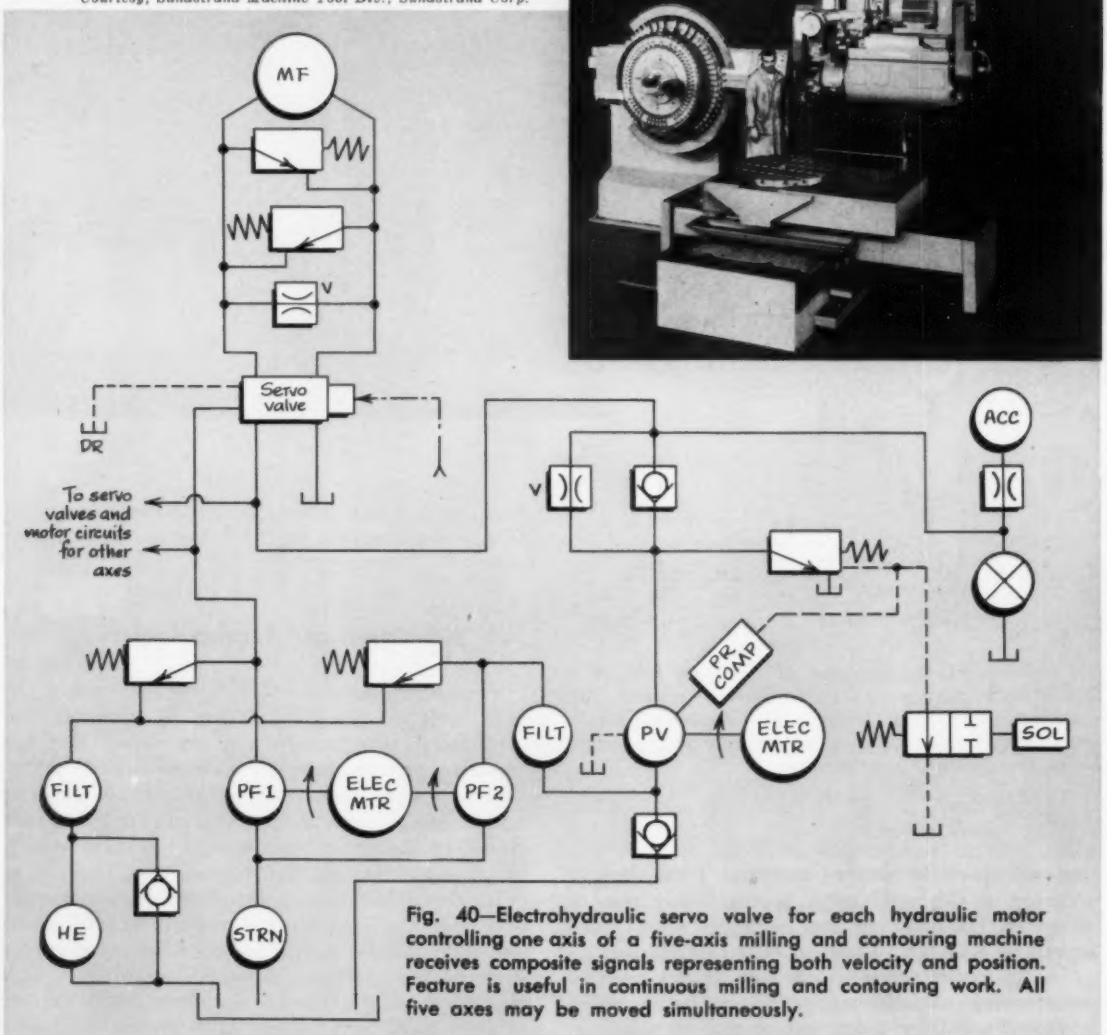


Fig. 40—Electrohydraulic servo valve for each hydraulic motor controlling one axis of a five-axis milling and contouring machine receives composite signals representing both velocity and position. Feature is useful in continuous milling and contouring work. All five axes may be moved simultaneously.

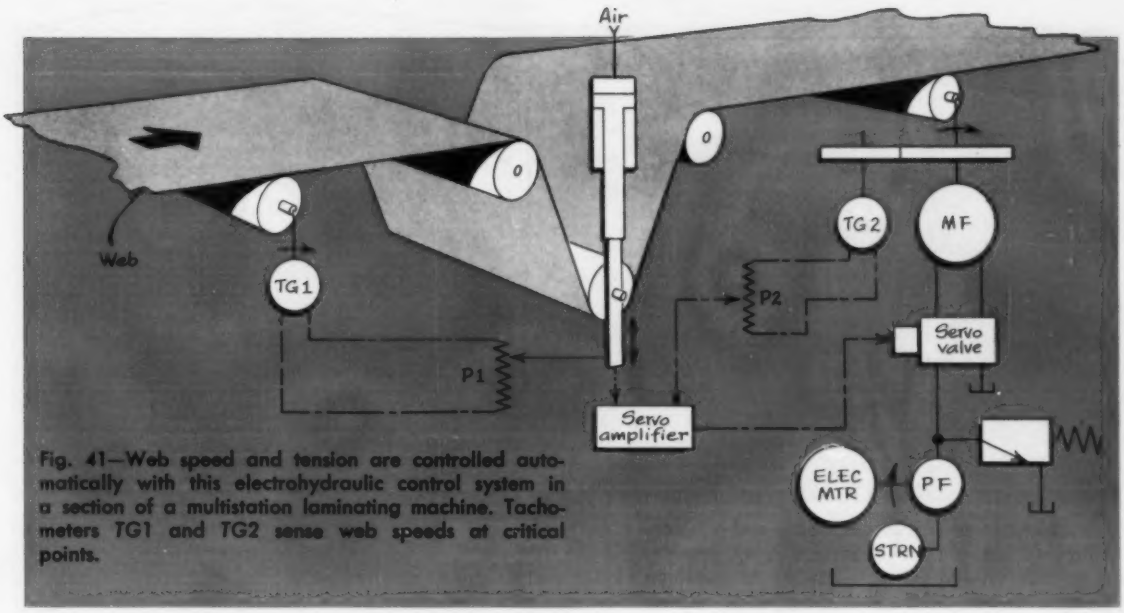


Fig. 41—Web speed and tension are controlled automatically with this electrohydraulic control system in a section of a multistation laminating machine. Tachometers *TG*1 and *TG*2 sense web speeds at critical points.

dancer signal allows for accurate tension control during rapid acceleration and deceleration of the machine. It also compensates for any nonlinearity in tachometer output signals when different speeds are selected. In the actual installation, total dancer travel is less than ¼ inch and provides a modification of the signal from *TG*1 of up to 10 per cent.

By installing an auxiliary power supply and additional potentiometers, *Fig.* 42, constant web tension can be maintained at all speeds including zero. With this arrangement, the dancer roll is used to position the arm of potentiometer *P*3. The signal from this potentiometer is fed to the servo amplifier where it augments the independent signal from *TG*1. Web speed and tension control actions during normal operations are the same as in the previous control scheme.

With the web stationary, the signal from *TG*1 falls to zero. However, a signal is still available from *P*3 because this component is energized by the power supply. This signal can be used to activate the hydraulic motor so as to maintain the position of the dancer roll at mid-range and thus hold constant tension in the stationary web.

▶ High Production Applications

An area of growing potential for the application of electrohydraulic servo systems is in multistation transfer machines. With today's dynamic markets, the frequency of design changes can create tooling and setup problems even with high production, automated lines. In this climate, the versatility and flexibility of servo systems are particularly attractive.

With packaged, servo controlled subunits, changeover of a production system to accommodate a new product is comparatively simple. Often, it involves little more than rearranging stations and reprogramming the controls. Use of sensitive, servo controlled, in-process gages also facilitates changeover and setup methods.

A servo controlled gaging and positioning system, *Fig.* 43, is used on a machine that checks engine block castings received from a foundry and drills locating holes for block machining. The blocks are sometimes misaligned because of a core shift during the casting process. If this condition is not detected, a boring tool may break into the water jacket when the cylinders are bored.

Engine blocks to be checked are first passed through a broaching machine where cuts are made on the engine head and crankcase surfaces. Before they are placed in the gaging machine, the blocks are inverted 180 degrees from their normal positions.

When a block is in place at the gaging station, a mechanical probe is inserted in a water jacket opening. On the opposite side of the block, an electrical probe is placed in another water jacket opening. The relation between the two probes forms a basis for detection of any misalignment caused by a core shift.

Movement of the electrical probe to place it in a water jacket hole operates a linear motion potentiometer that develops a voltage proportional to the position of the probe. This voltage, which is in effect a position command signal, is fed to a servo amplifier.

Another amplifier input signal is obtained from a feedback potentiometer driven by a hydraulic cylinder that positions a drill head. If the drill head is not in the position commanded, an error signal will be fed from the servo amplifier to the torque motor of a servo valve controlling the cylinder. The cylinder will then move the drill head to the com-

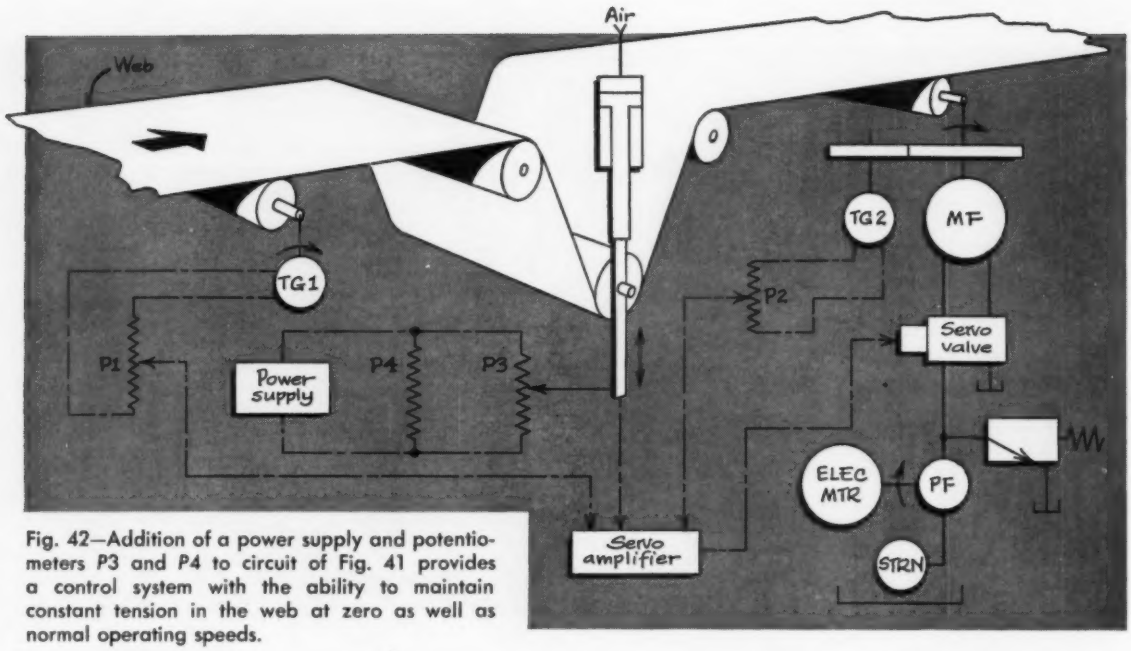
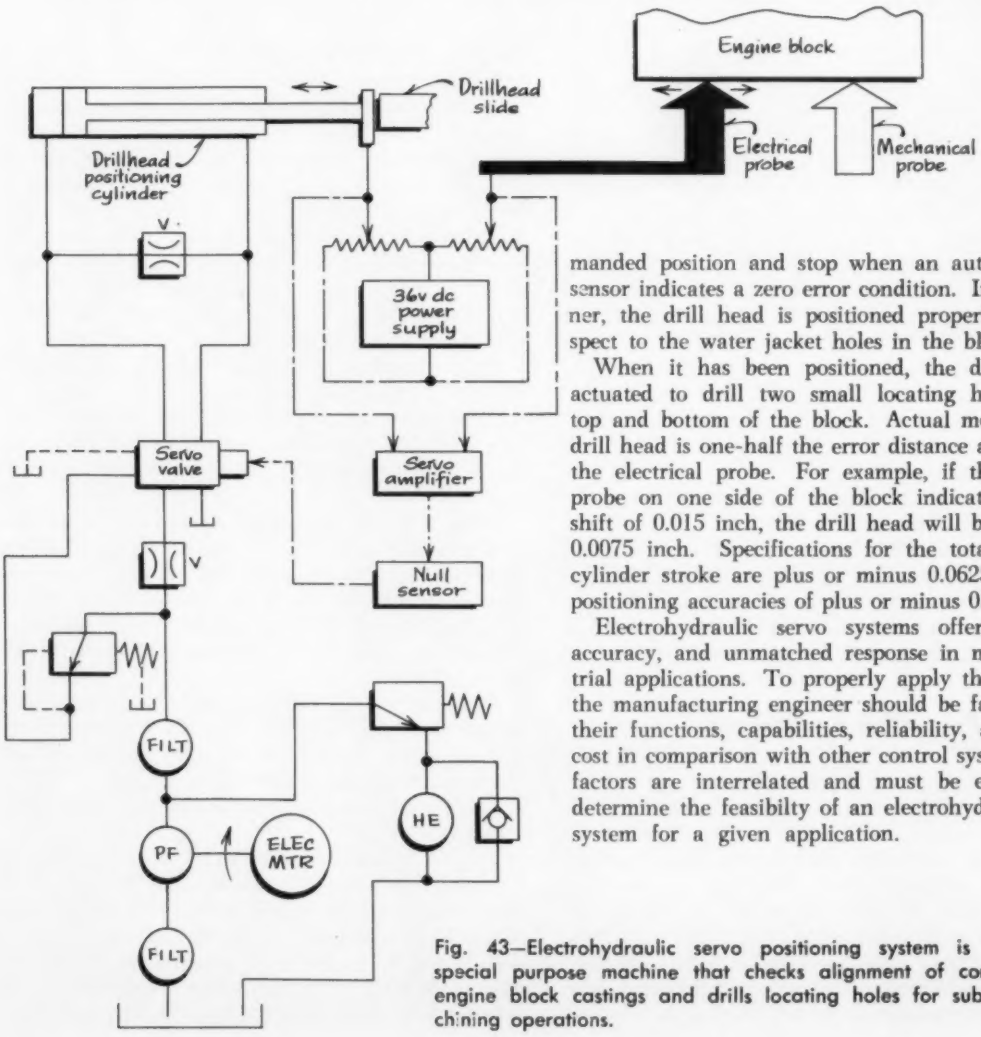


Fig. 42—Addition of a power supply and potentiometers P3 and P4 to circuit of Fig. 41 provides a control system with the ability to maintain constant tension in the web at zero as well as normal operating speeds.

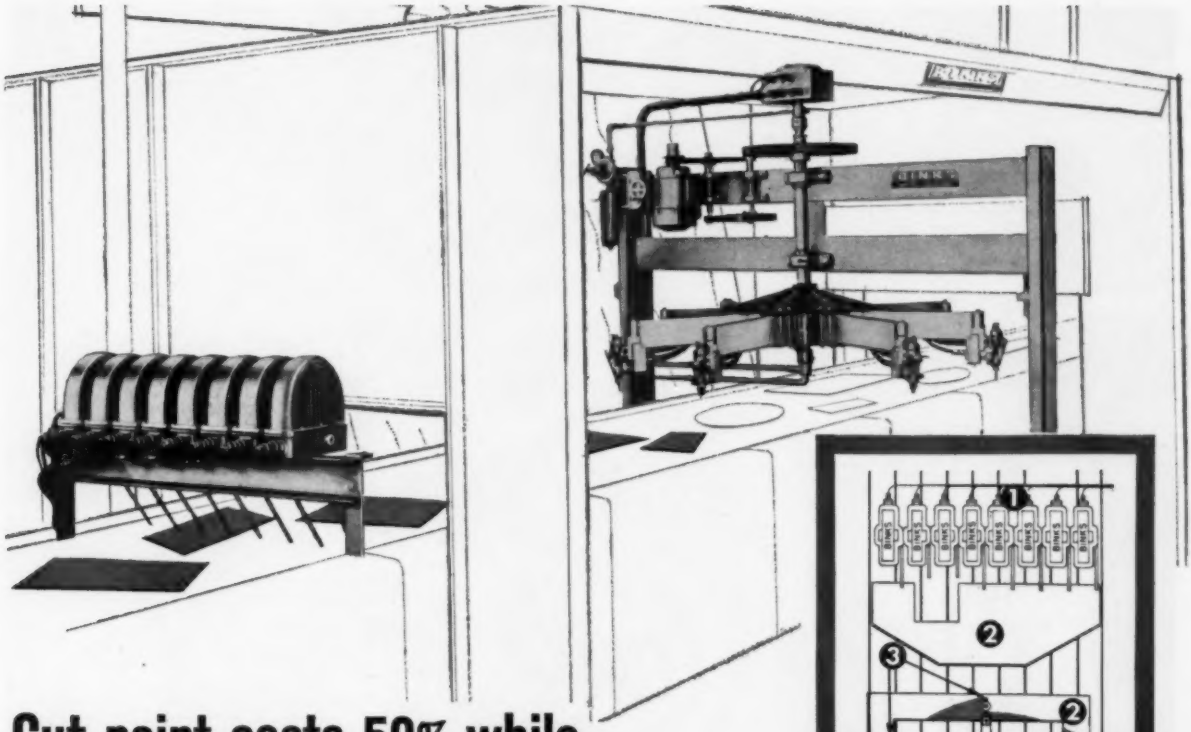


manded position and stop when an automatic null sensor indicates a zero error condition. In this manner, the drill head is positioned properly with respect to the water jacket holes in the block.

When it has been positioned, the drill head is actuated to drill two small locating holes in the top and bottom of the block. Actual motion of the drill head is one-half the error distance as sensed by the electrical probe. For example, if the electrical probe on one side of the block indicates a coring shift of 0.015 inch, the drill head will be moved by 0.0075 inch. Specifications for the total hydraulic cylinder stroke are plus or minus 0.0625 inch with positioning accuracies of plus or minus 0.001 inch.

Electrohydraulic servo systems offer flexibility, accuracy, and unmatched response in many industrial applications. To properly apply these systems, the manufacturing engineer should be familiar with their functions, capabilities, reliability, and relative cost in comparison with other control systems. These factors are interrelated and must be evaluated to determine the feasibilty of an electrohydraulic servo system for a given application.

Fig. 43—Electrohydraulic servo positioning system is used on a special purpose machine that checks alignment of cored holes in engine block castings and drills locating holes for subsequent machining operations.



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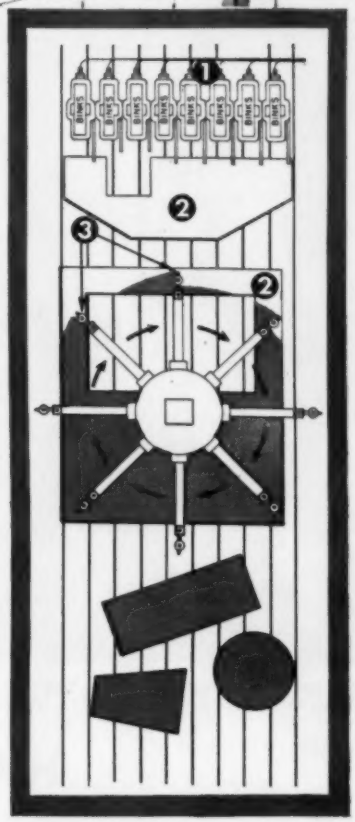

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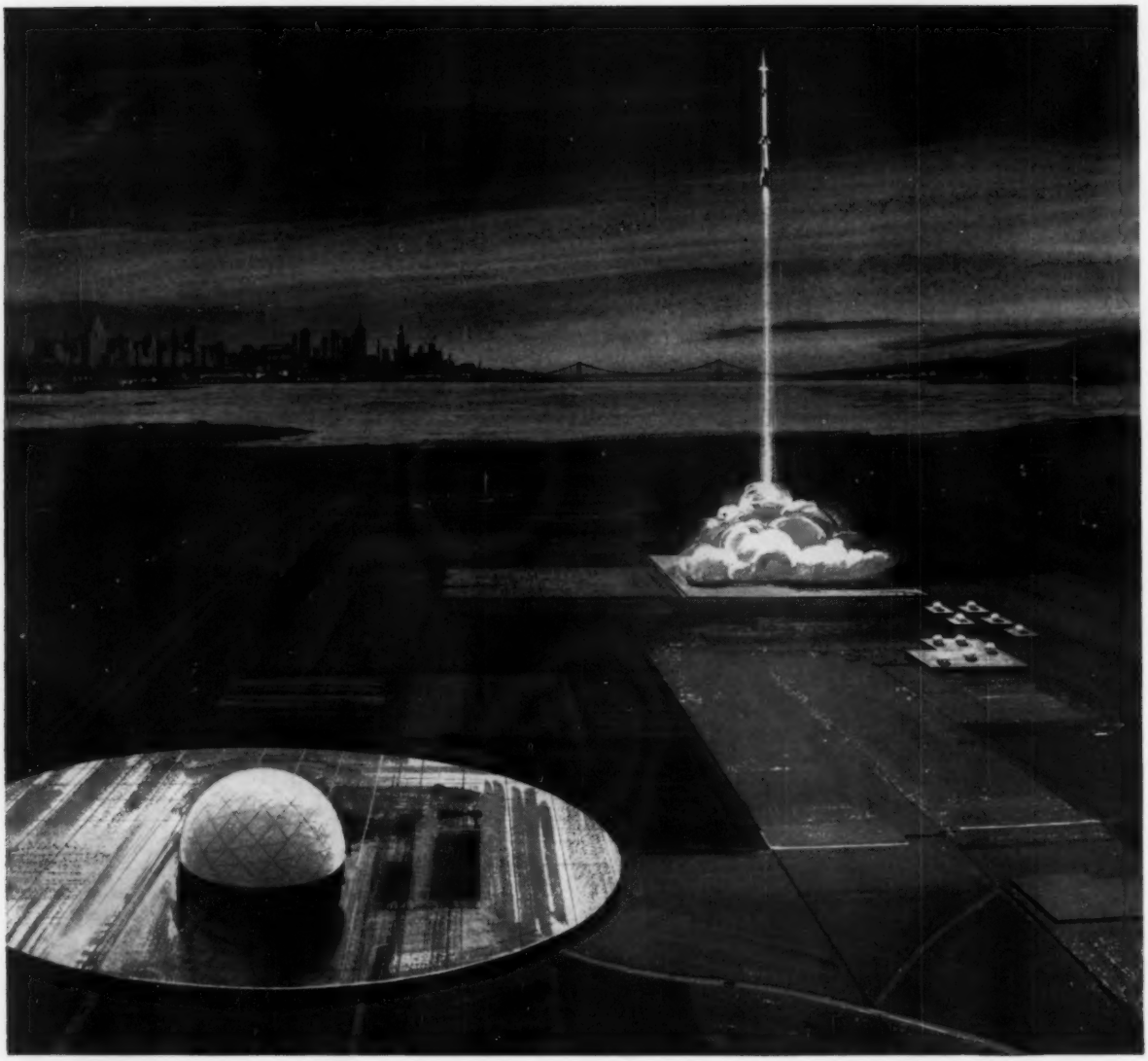
Circle 687 on Page 117



More than 450,000 pounds of thrust lifts the U. S. Army's Nike Zeus missile skyward in a cloud of vapor. The Nike Zeus missile being developed for the project by the Douglas Aircraft Company will be designed to intercept ballistic missiles traveling over 15,000 miles per hour, and destroy them at a safe distance from the defended area.

How do you stop an ICBM?

How do you detect, track, intercept—and destroy within minutes—an ICBM that is moving through outer space ten times faster than a bullet?

Bell Telephone Laboratories may have designed the answer: Nike Zeus, a fully automated system designed to intercept and destroy all types of ballistic missiles—not only ICBM's but also IRBM's launched from land, sea or air. The system is now under development for the Army Ordnance Missile Command.

Radically new radar techniques are being developed for Nike Zeus. There will be an acquisition radar designed to detect the invading missile at great distances. And a discrimination radar designed to distinguish actual warheads from harmless decoys that may be included to confuse our defenses.

The system tracks the ICBM or IRBM, then launches and tracks the Nike Zeus missile and automatically steers it all the way to intercept the target. The entire engagement, from detection to destruction, would take place within minutes and would span hundreds of miles.

Under a prime Army Ordnance contract with the Western Electric Company, Bell Laboratories is charged with the development of the entire Nike Zeus system, with assistance from many subcontractors. It is another example of the cooperation between Bell Laboratories and Western Electric for the defense of America.

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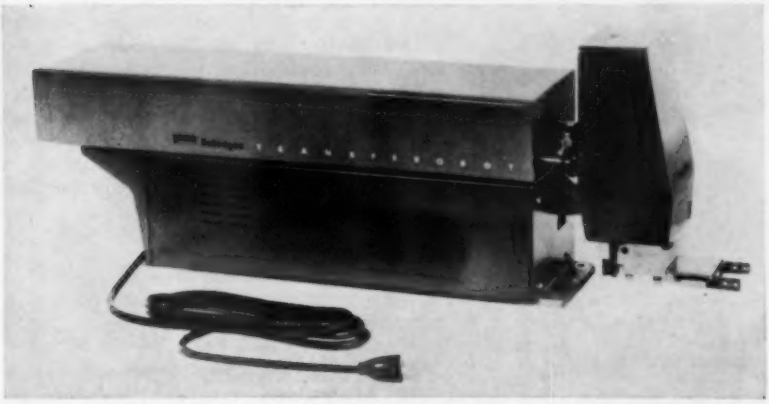
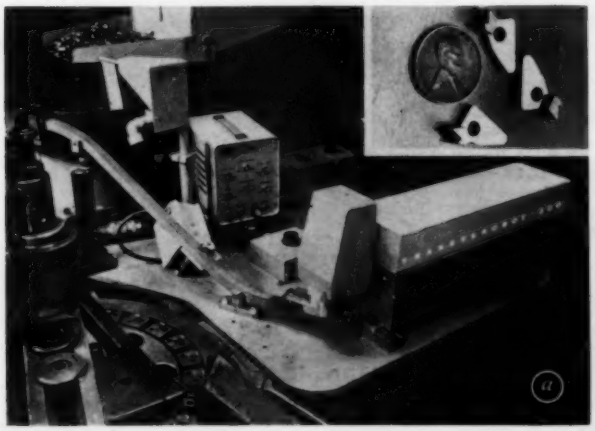
Programmed Handling Machine

DEVELOPED by U. S. Industries Inc., 250 Park Ave., New York 17, N. Y., the TransfeRobot 200 is capable of working on any assembly line under the command of its own programmed electronic controls. It has been utilized in companies manufacturing such varied products as clocks, business machines, razors, and automotive and electrical equipment. Available as standard off-the-shelf hardware, this general purpose automation machine can be programmed to many tasks merely by changing accessories. Basically, the machine consists of an arm and an actuator which can be fitted with many types of fingers and jaws, all under the control of a self-contained electronic control. The unit uses its fingers to seize, move, position, and relinquish the workpiece it is handling. With the use of an accessory swivel, it acquires a wrist which enables it to perform virtually any required set of motions within the limits of its reach. Upon command of the electronic director, the machine performs its own tasks and orders other machines to act as well. It is thus in constant communication with the rest of the production line. If the electronic control indicates that something has gone wrong in the work program, the machine stops, and by means of flashing lights or buzzers an operator is told to locate and correct the error.

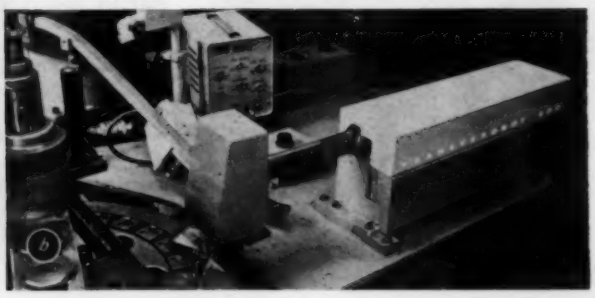
Circle 401 on Page 117

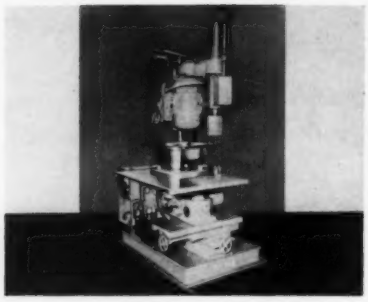


Automatic industrial robot is designed for many types of assembly line work. The arm is shown in retracted position, with the actuating head (right) waiting to be fitted with one of many types of fingers or jaws for grasping pieces to be fabricated or assembled.



Photographs show how the TransfeRobot 200 (a) picks up an electric typewriter component (inset) as it is delivered down a chute from the feeder, then (b) transfers the part into the nest of an automatic countersink machine. The machine's arm extends and turns as it carries the part from chute to machine tool.





SEMI-AUTOMATIC SINK GRINDING AND POLISHING MACHINE

Machine has been designed to automatically finish the inner side contours of stainless steel sink bowls. It basically consists of a retracting spindle type adjustable lathe and a roller feed unit mounted on a common base. The abrasive polishing wheel is mounted on the lathe spindle. Sinks of various sizes can be polished on this machine through the use of separate interchangeable fixtures. The worktable is rigidly constructed and table size can be varied to accommodate the largest size sink bowls. This grinding and polishing machine incorporates a safety mechanism which prevents the worktable from moving into or out of the unload position when the spindle is not in the retracted position. **Acme Manufacturing Co.**, 1400 E. Nine Mile Rd., Detroit 20, Mich.

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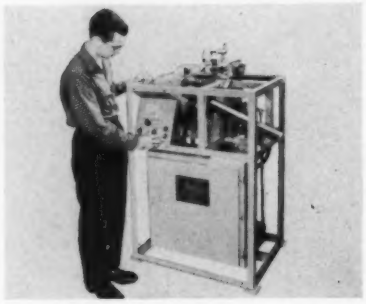
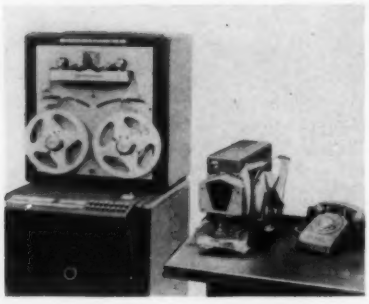


ELECTRONIC WEIGHT COMPARATOR UTILIZES COMPARATIVE WEIGHT PRINCIPLE

Production line electronic weight comparing system automates the selection and screening of parts and materials by weight comparison. When used in processing or production operations, it handles a continuously moving stream of parts or materials, rapidly weighs each item individually, automatically compares this weight to within ±1 gram of a predetermined proper weight, and either accepts or rejects the item, depending on how it meets the weight requirement. Accepted items are automatically passed on to the next production step. As presently designed, the system handles items weighing up to 5 lb. **Atronic Products Inc.**, West Conshohocken, Pa.

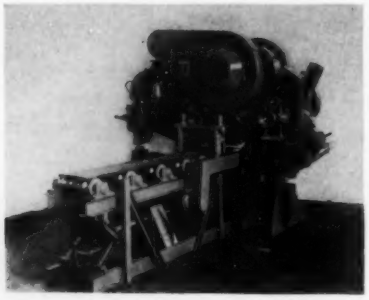
Circle 403 on Page 117



DATA PROCESSING SYSTEM

In addition to functioning with a Bell System Data-Phone 200 for high-speed transmission over regular dial exchange networks, Dial-o-verter data transmitting system is available for use with private lines. It is compatible with broadband microwave facilities. The system checks a line for acceptable transmission before it permits data to be sent. When an error is detected, it requests immediate retransmission, or identifies the block of data for later retransmission. Data in any media can be transmitted and received. System features: Transmitting and receiving speeds up to 1500 words per minute and 15,000 characters per second; unattended operation; and ability to transmit in one medium at one point, and have it received in another medium at the other point. **Digitronics Corp.**, Albertson, N. Y.

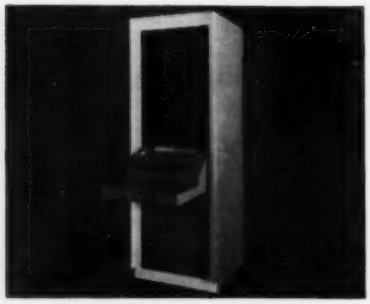
Circle 404 on Page 117



SHEAR PROVIDED WITH AUTOMATIC FEED TABLE

Line of Steelmaster Universal Ironworkers are now available with automated feed-tables and back-stops. The new attachment will permit automatic shearing to a predetermined length up to 40-ft with infinitely variable increments. Sections handled include H-beams, I-beams, angles, etc., from 3 inch up to 11 inch dimensions. An automated gaging system for the punching end of the machine is also available. **Pathex Inc.**, 1006 Prudential Bldg., Buffalo 2, N. Y.

Circle 405 on Page 117



CIRCUIT ANALYZER CHECKS WIRE CONTINUITY

NIFTE circuit analyzer analyzes from 500 to 18,000 circuit points automatically. It checks wire continuity of complex electronic circuits by comparing two units against each other. The unit will display steady light pattern to enable qualification of the "master" to wire lists. When comparing one unit against the other, circuitry not in agreement will cause the panel light to flash, giving connector and pin location together with nature of the error. This equipment eliminates the need for tape or card programming and requires no matrix chart or plugboard programming. Test speeds of up to 5000 circuit points per second may be obtained. **Autonetics—Industrial Products, Div., North American Aviation Inc.**, 3400 E. 70th St., North Long Beach, Calif.

Circle 406 on Page 117

Another first from Standard Conveyor

New continuous vertical conveyor revolutionizes floor-to-floor movement

Escaveyor* self-loads, self-unloads, lifts products straight up or down without tipping or jarring. Provides smooth up, down, or reversible service.

How Escaveyor speeds production. Here is the answer to your big need for a fast, continuous flow of commodities from floor to floor. Escaveyor moves commodities at a steady rate of 8 to 10 loads per minute.

How Escaveyor saves space. Escaveyor lifts packaged or unit commodities rapidly from floor to floor with the continuity of a belt conveyor. Yet your product always rides level. And look at the huge saving in space! It takes even less floor space than a conventional monostrand or straight-lift conveyor! Escaveyor's size is tailored to fit your package.

How Escaveyor costs less. Escaveyor actually costs less to purchase and install than practically any other type of lift. It requires less manpower because no manual loading or unloading is required. You also save many square feet of valuable floor space.

Free brochure. Send for free Escaveyor brochure! It tells how Escaveyor works, and how it can solve vertical material handling problems for *you!* Get your copy from Standard Conveyor Company, Dept. 303-J, Second St., North St. Paul 9, Minnesota, or from your nearby Standard Conveyor sales representative.

*patent pending

Standard Conveyor

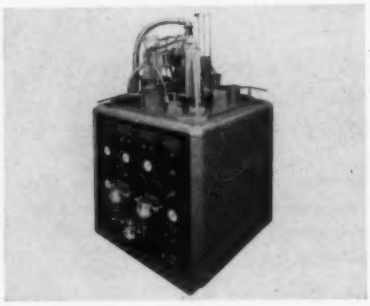
Sales and Service in over 40 Cities
Consult your Yellow Pages

Circle 688 on Page 117

MACHINE PROCESSES 1000 TRANSISTOR LEADS AN HOUR

Machine automatically straightens, cuts, and notches transistor leads. It is available in two models—a transistor straightener, Model AL3S, and a cutter-notcher, Model AL3NS. Both machines are designed especially to prepare transistors for high-speed precision parts assembly. Their operations do not roll, twist, or affect the seals or leads electrically. Both models are designed for bench mounting. Power requirements are 110 volts, 60 cycle and 80 psi of compressed air. **Design Tool Co.**, 1055 Stewart Ave., Garden City, L. I.

Circle 407 on Page 117



MACHINE INSPECTS LIP SEALS FOR PROPER DIAMETERS AND PRESSURES

Inspecting machine automatically inspects lip seals to find and reject potential leakers. Any seal that is too large or too small in lip diameter or lip pressure is a potential leaker. The Sealector can check up to 1200 seals an hour for proper diameters and pressures. It checks the seals by clamping them in a series of three adapters and gaging the flow of compressed air past the seal lip. The seals are carried through the machine's stations by an air-operated turret table. The number of rejected and accepted seals are totaled on counters on the front of the machine. This machine uses 100 v ac, 60 cycle current, and compressed air at 60 psi or more. **General Motors Research Laboratories**, Warren, Mich.

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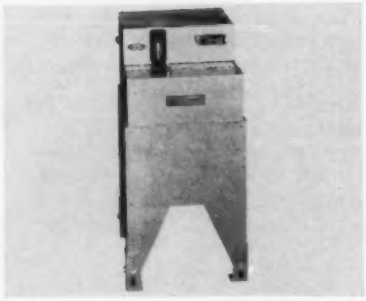

CHECKWEIGHER OPERATES AT SPEEDS UP TO 200 PACKAGES PER MINUTE

Model 1205-S Selectrol automatic high-speed checkweigher is specially designed for installations where floor space is at a premium. Over-all dimensions of the unit are 20 inches deep and 22 inches long, with an adjustable height of 35 to 40 inches. This checkweigher will weigh, classify, and separate packages by correct weight, over weight, and under weight at speeds up to 200 per minute depending on the accuracy requirements and product handling characteristics. Standard models will weigh packages in a range up to 12 oz. Checkweigher features a precision scale with a 1 to 1 ratio even balance lever to provide high sensitivity with minimum effect from floor vibrations. **Exact Weight Scale Co.**, 541 E. Town St., Columbus 15, Ohio.

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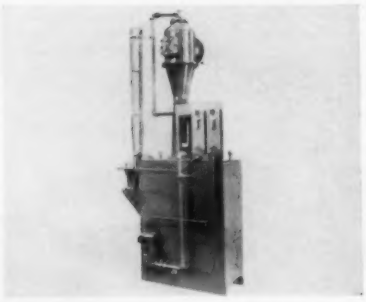

PORTABLE GAS SCRUBBER DEVELOPED FOR PILOT PLANT USE

Especially designed to clean gas discharged during laboratory tests or pilot plant operations, portable gas scrubber features an SK-4014 scrubber-separator. This unit combines an ejector-venturi gas scrubber with an inertial-impact type separator, in one integral part. This construction provides improved particle separation as well as the virtually complete elimination of moisture carryover. Package includes storage facilities for up to 150 gal of water or caustic solution. A centrifugal pump, blower, piping, stack, rotameter, electrical combination starter-disconnects, and a removable mist eliminator are also supplied. **Schutte & Koerting Co.**, Dept. JA-38, Cornwells Heights, Bucks County, Pa.

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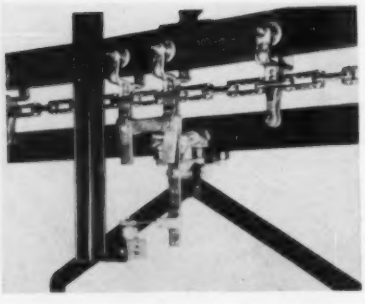

POWER-AND-FREE CONVEYOR UTILIZES NEW CONCEPTS OF CONTROL

Power-and-free conveyor system utilizes several new control and selectivity devices designed for gravity load-carrying and accumulation (storage) lines. The conveyor employs components of standard R-K 228 conveyor systems and can be used in conjunction with these systems. The power-and-free equipment provides a combination of transporting, accumulating, load-spacing, station-selecting, and dispatching operations suitable for industrial processing and warehousing and for service industries. Among the devices that bring control and selectivity to the system are: Gravity flow retarder, indexing trolley stop, automatic feeder unit, mutiple station selector (illustrated), automatic tongue switch, and vertical drop section. **Rapistan-Keystone Inc.**, 350 Rapistan Bldg., Grand Rapids, Mich.

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EDLUND MODEL NPB

PRINTED CIRCUIT BOARD DRILLING MACHINE

DRILL PRINTED CIRCUIT BOARDS FASTER, CHEAPER, AND MORE ACCURATELY

Now High Speed, Versatile, Tape Controlled Machine drills Printed Circuit Boards with amazing accuracy in a wide variety of material at low cost.

This High Production drilling machine is actually 16 drills in 1, it drills four boards or stacks of boards simultaneously, operating at 50 cycles per minute under average conditions. **Time Saving Versatility** is featured with 4 independent air feed units in each drilling cluster, each unit capable of carrying a different drill size and operating at spindle speeds up to 22,000 RPM. **The Tape Controlled point positioning** table and drill units assure maximum accuracy and reliability. Now drilling speed and size changes are done automatically, eliminating time consuming manual tooling and set-up.

Printed Circuit Boards Drilled on Edlund Machine

Edlund Model TPR Programmer for Tape

EDLUND PROGRAMMER PREPARES TAPE DIRECTLY FROM ART WORK

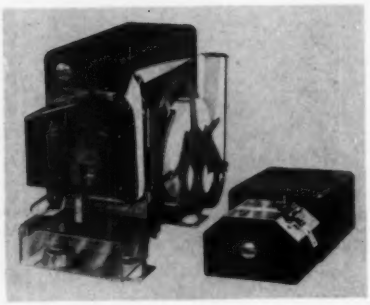
This unique Programmer prepares 1" 8-channel tape **DIRECTLY** from the draftsmen's art work at a **LOW INITIAL** and **LOW UPKEEP** cost.

ELIMINATE MASTER BOARDS and **SAVE** by preparing tape directly from art work. **HIGH SPEED PERFORMANCE** locates up to 30 positions per minute. **MAXIMUM ACCURACY AND RELIABILITY** are the result of the unique design which corrects errors in the art work and keeps the programming process on the desired grid automatically. **INDEPENDENT OPERATION** permits tapes to be prepared when drilling machine is in use. **COMPLETE VERSATILITY** is provided by precision interchangeable slides allowing the Programmer to handle grid sizes down to .025" including unusual grids.

Write for FREE Descriptive Bulletins

EDLUND
MACHINERY COMPANY
Division of Harsco Corporation Cortland, New York

Edlund Representatives in Major Cities



HIGH-SPEED TAPE PUNCH AND TAPE READER

Two, high-speed 100-characters-per-second tape units are designed for use in message and data communications, including various computer applications and other data handling communications uses. Designated the BRPE tape punch and the CX tape reader, these units operate as a complementary matched pair for use in high-speed, tape-to-tape communications systems. The punch is available in two models: One operates at a 5 level code; the other is adjustable to 6, 7, or 8 code levels. The CX, which adjusts to 5, 6, 7, or 8 levels and reads either fully perforated or chadless tape, can be used to transmit data collected from the BRPE or slower speed equipment. The BRPE's tape output, in turn, can be relayed by the CX or by compatible equipment at slower speeds. **Teletype Corp.**, Dept. SP-12, 5555 Touhy Ave., Skokie, Ill.

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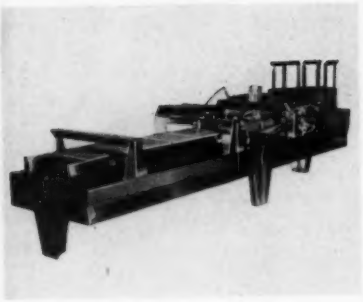

PNEUMATICALLY OPERATED PACKAGING MACHINE

This machine will automatically select, feed, open, and form a case, pack it in any desired pattern, and seal it. It occupies less than 100 sq ft of floor area. Stainless steel construction makes it ideal for use in the dairy and food industries. The machine utilizes a system for applying adhesive that cuts maintenance to a minimum. Its pneumatic drive reduces moving parts to a minimum. **Schroeder Machines Corp.**, P. O. Box 1123, Syracuse 1, N. Y.

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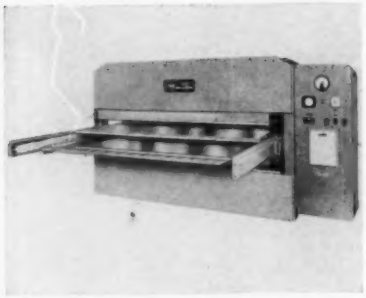

SHUTTLE LOADING PRESS PROVIDES FOR FRONT FEEDING

Model SPA-200 automatic shuttle loading press is especially designed to accommodate jobs where production is governed by lay-up time rather than pressing time. It is equipped with one fixed and two moving platens. Cycle time is infinitely adjustable from 0 to 30 minutes. Design of the machine provides for feeding from the front only, permitting back-to-wall installation and reducing floor space requirements. Optional platen heating allows maximum adaptability to individual installations—platens can be arranged for heating by electricity, steam, or hot water. The machine may also be used for cold pressing and can accommodate particularly long curing cycles. **Yates-American Machine Co.**, North 4th St., Beloit, Wis.

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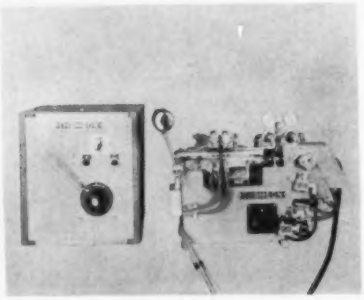

FLASH WELDER FOR WELDING METAL CUTTING SAW BLADES

Compact 4 kva automatic flash welding unit has been designed to meet severe strength and anneal criteria in welding high speed, metal cutting saw blades of tungsten or molybdenum. It features adjustable work clamps, an integral annealing system, and a Synchromatic mechanism that automatically controls the synchronization of flashing and upset to produce high quality welds. Air operated individually by pushbutton, the work clamps exert 1200 lb of force at 80 psi on the work. A special adjustable socket arrangement in the upper jaws defines the line of engagement with the stock and insures that the clamp pressure is imposed equally across its width. The anneal time of this F-00 machine is 1 to 3 minutes. **Thomson Electric Welder Co.**, 161 Pleasant St., Lynn, Mass.

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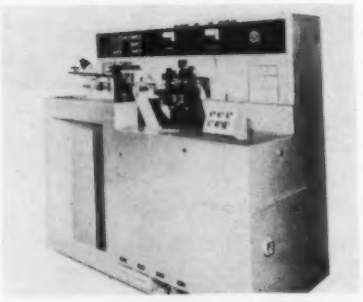


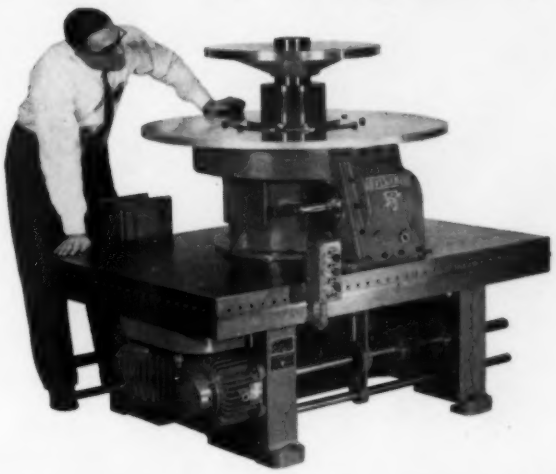
INSPECTION SYSTEM FOR CHECKING VARIOUS SIZES OF MAGNETS

Operating at speeds of up to 1200 parts per hour, automatic inspection machine gages the length and diameter of magnets and sorts them into acceptable and reject categories. It can be quickly adjusted to handle various part sizes. Use of standard gage heads and electronic modules assures high reliability, 100 per cent repeatability, and ease of maintenance. Lights and gages on panel give continuous visual presentation of the operation. **Radio Corp. of America**, 12605 Arnold Ave., Detroit 39, Mich.

Circle 416 on Page 117

NOW the only rotary indexing chassis with built-in lever pivot shafts

Provides more tool-driving capacity than anything in its field



The high cost of automation may not be as high as you think.

Not if you get your automation program's basic building block—an automatic transfer machine—from Sylvania.

For Sylvania automatic transfer machines cost less than machines which can meet their productivity and precision standards. And they're more precise and more productive than other machines in their price class.

FOR EXAMPLE

Our Heavy Duty Rotary Indexing Chassis is a case in point.

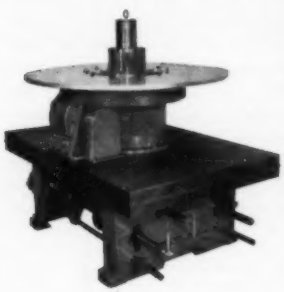
It's the *only* rotary transfer machine on the market with lever pivot shafts built in.

This makes it far easier to synchronize or time your automated operations, far less expensive, too.

What's more, with two full-length 1⅝" diameter camshafts keywayed throughout and supported by heavy-duty sealed ball bearings, we think this Sylvania machine provides more tool-driving capacity than any machine of similar quality and price.

THINKING ABOUT AUTOMATING?

If you are, you probably know that every automation program must start with a transfer machine. If it's a good one, you'll be off to a good start. If it's not, you're defeating your purpose because your program will probably never be satisfactory.



Sylvania makes several different kinds of transfer machines. By changing the tooling, they can be adapted to any conceivable production operation. You can change products without changing transfer machines.

We'll provide you with free consultation to help get your automation program started—even recommend experienced designers and manufacturers of tooling if you don't have the facilities to do the job.

Since a good transfer machine will last 30 years or more, it pays to get the best. We think ours are, because we've never been able to find one that will meet our accuracy standards for the manufacture of lamps, tubes and fine electronics equipment. That's why we build our own.

We'll be glad to send one of our automation sales engineers to consult with you on your automation program and needs. If you'd like more details on the transfer machines we build, send for our free brochure. Naturally, there's no obligation.

SYLVANIA LIGHTING PRODUCTS
Equipment Development Plant
121 Loring Avenue, Salem, Mass.

Please send me free brochure of:

☐ Rotary ☐ 44-Station Conveyor and 80-Station Conveyor ☐ Transmissions

Name_____

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Company_____

Address_____

City_____ Zone_____ State_____

☐ PLEASE HAVE SALES ENGINEER CALL FOR APPOINTMENT

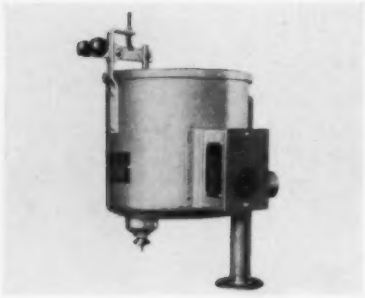
SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

Circle 690 on Page 117



SOLDER MELTING UNITS SUITABLE FOR VARIETY OF APPLICATIONS

These units are used in industry for many different applications, including production tinning for electrical components, removal of resin-based insulation, as well as for providing a source of molten solder for laboratory or production operations. They are particularly suited for dipping operations in printed circuitry fabrication. All units are equipped with a blanket-type heating element which distributes heat evenly at minimum watt density to bottom and side walls. Even heat distribution eliminates hot spots and reduces solder decomposition. Available in either single-heat or three-heat (high, medium, low) and larger sizes with automatic thermostatic control, the units operate on voltages of 115, 208, 230, single phase, 50 or 60 cycle. **Sta-Warm Electric Co.**, Ravenna, Ohio.

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TROLLEY CONVEYOR LUBRICATOR FEATURES EASY PORTABILITY

Portable-air-powered trolley conveyor lubricator will lubricate from 100 ft to 100 miles of conveyor on one filling of lube. It can be installed while a conveyor is running. The unit consists of a mounting frame that is welded to the existing conveyor rail; right and left hand lubricator sections, air and lubricant supply lines, and a lubricant pump mounted on a mobile cart to provide floor-level control. This lubricator will service trolley conveyor wheels with no maximum limit to wheel spacing, and with no limit to irregular wheel spacing. The unit can be installed permanently in a conveyor line. **Industrial Div., Aro Equipment Corp.**, Bryan, Ohio.

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PNEUMATIC-HYDRAULIC NUMERICAL CONTROL SYSTEM

Based upon pneumatic-hydraulic principles, this tape-reading numerical control system provides point-to-point positioning for drilling and tapping and for straight line milling operations. It is presently used with a line of Bridgeport milling machines and with a Burgmaster turret drilling machine. It may also be used on drilling, and tapping, and boring machines. Speed of operation is 350 to 700 inches per minute of table travel. Absolute positioning accuracy is ± 0.0005 inch; repeatable positioning accuracy ± 0.0003 inch. Zero adjustment is ± 0.020 inch. The machine utilizes a pneumatic block reader and one-inch wide, eight channel tape. Binary coded decimal, fixed block format tape code is used. **Moog Servocontrols Inc.**, East Aurora, N. Y.

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DOUBLE TOOL PLATE INDEXING MACHINE CHASSIS

Turret indexing machine chassis employs double overhead plates for mounting and actuating operational tooling. Series SD is especially engineered for high-speed, comparatively light, sequential assembling and processing operations. It is offered in a wide range of turret diameters, index positions, and work cycles. Utilizing the dual motion method of multiple piece-part assembly, this self-contained chassis includes positive parts control, reduced jamming potential, design simplicity, tooling accessibility, and tool standardization. Two mounting options are available: With motor and drive components mounted in the floor base below the chassis, or with both units mounted in line with the input drive shaft and on the top surface of the floor base. **Swanson-Erie Corp.**, 816 E. Eighth St., Erie, Pa.

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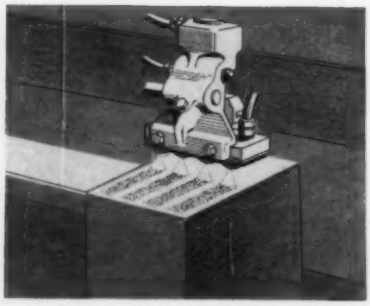


GLUE SPRAY KIT INCLUDES SPRAY GUN WITH MULTIPLE ORIFICES

Glue spray kit that operates with either resin or dextrin adhesives includes a spray gun (illustrated) equipped with multiple orifices permitting position as close to the box flaps as $\frac{3}{4}$ inch. This makes possible more accurate control of the glue pattern. The spray gun gives precision control of adhesive by putting down the glue in tiny droplets in the exact amount needed. Each droplet is flattened in compression, completely covering the area desired. This spray gun is adaptable to existing spray kits, which have proven successful on corrugated box assembly lines in a number of different industries. The spray kits are available in two-gun or four-gun units so that tops or bottoms can be sprayed separately or simultaneously. **Huntingdon Industries**, Bethayres, Pa.

Circle 421 on Page 117

OPENING NEW HORIZONS

. . . in economical power application

98% PLUS OPERATING EFFICIENCY
MORE POWER PER CYLINDER DOLLAR
PROVEN LEAKPROOF OPERATION
GREATEST SELECTION EVER OFFERED
SAFE UNDER SEVERE LOADS
SAFE WITH ALL KNOWN HYDRAULIC FLUIDS
SAFE UNDER TEMPERATURE EXTREMES
DAMAGE-PROOF PISTON RODS

Flick-Reedy . . . *Winner of "Plant of the Year" Award and "Silver Anvil" Public Relations Award*

Miller

MORE SAVINGS!

Our ultra-modern, new "Plant of the Year" with its special facilities and operating economies enable us to offer an **extra 10% price savings** on our big "stock" selection of:
Model "H" (Hyd.) Cylinders, 1½" through 8" bores;
Model "J" (Hyd.) Cylinders, 1½" through 14" bores;
Model "A" (Air) Cylinders, 1½" through 14" bores.
Strokes up to 36", cushioned and non-cushioned.

Full Details On Request

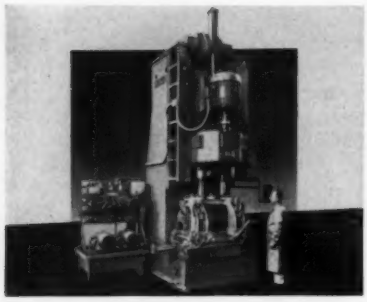
Miller Hydraulic Cylinders make impossible applications look easy. With Teflon Seals, Case-Hardened Rods (50-54 Rockwell C), Patented "Shef" Tubing End Seals, and other exclusive *standard* features, these cylinders are practically damage-proof, are ultra-dependable under pressure and temperature extremes, and provide leakproof sealing with ALL hydraulic fluids. Built to *exceed* J. I. C. Specifications, these cylinders are achieving new highs in production and operating economies in thousands of plants. Two great lines: Power-Packed Model H for 3000-5000 psi and Job-Rated Model J for 500-2500 psi. All bores, strokes and mounting styles. Big "Stock" selection for immediate shipment at substantial savings.

Write for literature.

R

MILLER FLUID POWER
DIVISION OF FLICK-REEDY CORPORATION
7N026 York Road, Bensenville, Ill.
AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

Circle 691 on Page 117



VERTICAL BORING MACHINE

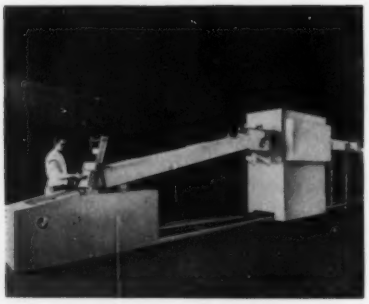
Machine is capable of rough boring 6-cylinder engine blocks weighing 700 lb unmachined. For maximum rigidity the machine frame is of welded fabrication, fusing the bed, column, and ways into a one-piece, heavily reinforced structure. Spindle carrier design features versatility and ready adaptation to new spindle spacing should cylinder block revision alter distances between cylinders. In operation, the cylinder block is rolled into the fixture from a conveyor, located manually, and hydraulically clamped. After two index movements, boring of all six cylinders is complete. **Continental Tool Works, Ex-Cell-O Corp.**, 1200 Oakman Blvd., Detroit 32, Mich.

Circle 422 on Page 117

SKID PACKAGING STATION

Production-line packaging of skids of paper is made possible by this semi-automatic packaging station. This system is built around a wrapping station, which predrapes the required number of wraps around the skid as it moves along the conveyor, and a strapping station, which incorporates a CSF20 compression strapping machine and a skid notch feeding device. **Signode Steel Strapping Co.**, 2600 N. Western Ave., Chicago 47, Ill.

Circle 423 on Page 117



MESH BELT FURNACES AVAILABLE IN 17 MODELS

Line of Hump-Type mesh belt furnaces is ideally suited to the processing of a wide variety of metals. With heating chamber lengths ranging from 3 to 11 ft and belt widths from 6 to 36 inches, these furnaces are especially efficient in maintaining low dew points during continuous brazing, annealing, hardening, and sintering operations. Materials to be treated can be light or medium weight—in multiple sizes and shapes. Constant time-temperature cycles assure uniform treatment of materials. Variable speeds allow treatment of materials of different thicknesses and time-temperature requirements. Electric models with nickel-chromium, silicon-carbide, or moly heating units are available with or without muffles. Gas models are equipped with muffles. **Harper Electric Furnace Corp.**, 110 Pearl St., Buffalo 2, N. Y.

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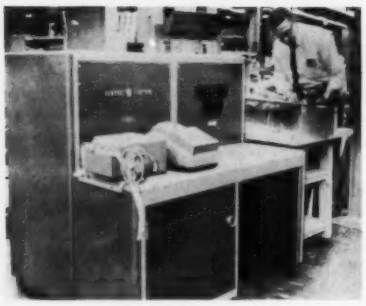

PROGRAMMED AUTOMATIC CIRCUIT TESTER SCANS 540 POINTS PER SECOND

Capable of scanning up to 3600 points in a wire harness or assembly, this programmed automatic circuit tester (PACT), assures that proper points are interconnected and that there are no missing or extra wires. It is programmed from a punched tape prepared from a wiring table and includes proper sequencing of points, all engineered circuit connections, and circuit numbers. The tester checks for continuity, indicates error by stopping the test, showing circuit point number, tape block number, extra wire, missing wire. Scan time for the condition of no programmed, missing, or extra wires is 6.7 seconds. Scan time for single programmed wire is 10 seconds. With an optional printer, the tester can print out errors with locations to enable uninterrupted completion of test. **General Electric Co.**, Schenectady 5, N. Y.

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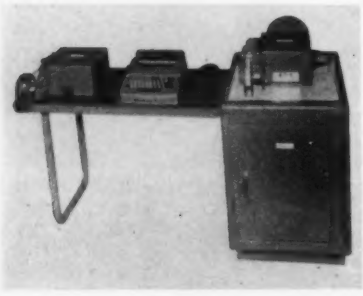


CODE TAPE PUNCH/VERIFIER SYSTEM

Model D875 Universal code punch and verifier system is designed to provide a fast, accurate, and economical means of manually punching and verifying from an original document into paper tape machine language. It has combined tape keypunching and verifying functions into one integrated system. This system punches and verifies for all systems—5, 6, 7, or 8-channel tape, and code structure. It is capable of flexible tape duplication—automatically or intermixed with punching and verifying—at any speed up to 20 characters per second. It is also capable of operation in any one of four different modes. **Systematics**, Hawthorne, Calif.

Circle 426 on Page 117

in machine design or modernization...

Fawick FSPA improves machine performance

...with increased production through higher machine speed

Fawick Standardized Press Applications may be used as original equipment or for modernization on power presses and other machinery where productivity depends on cycling speed. Instant air clutch action and fail-safe braking allow faster operation without sacrificing safety or precision.

...precision control

FSPA provides split-second starts and stops that assure accurate automatic control of single, continuous or inching operations.

...manpower and machine protection

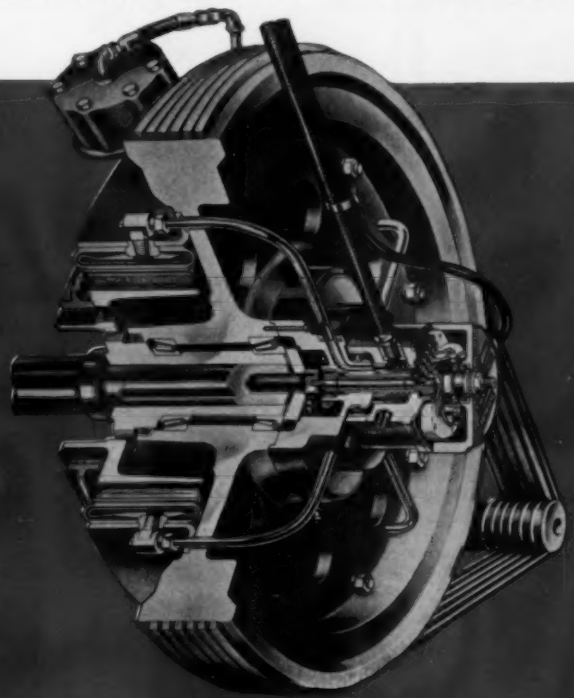
FSPA eliminates damaging backlash, providing maximum protection for intricate tooling. The spring-applied brake engages immediately in case of air or power failure, preventing costly jamming and insuring operator safety.

...installation flexibility

FSPA can be installed quickly and easily in both OEM and user applications. The package unit may be mounted on a common drum as shown below, or the brake may be mounted at another location on the shaft. Installation can be made with only minimum preparatory work.

...and unmatched low maintenance

Fawick drum-type air clutches have few moving parts and require no lubrication. The self-adjusting 360° friction surface insures long friction life and continuous new unit performance under the most demanding conditions.



FAWICK STANDARDIZED PRESS APPLICATION includes constricting type CB Airflex Clutch, spring-applied CS Brake, Timing Rotorseal and high-speed clutch control — designed into a package unit which meets the toughest requirements for fast, accurate power transmission. FSPA is produced in 26 standard sizes with torque capacities from 2,040 to 172,000 in.-lbs. at 75 psi.

For complete information on how Fawick can simplify your clutch problem, contact your nearest Fawick representative or the Home Office.

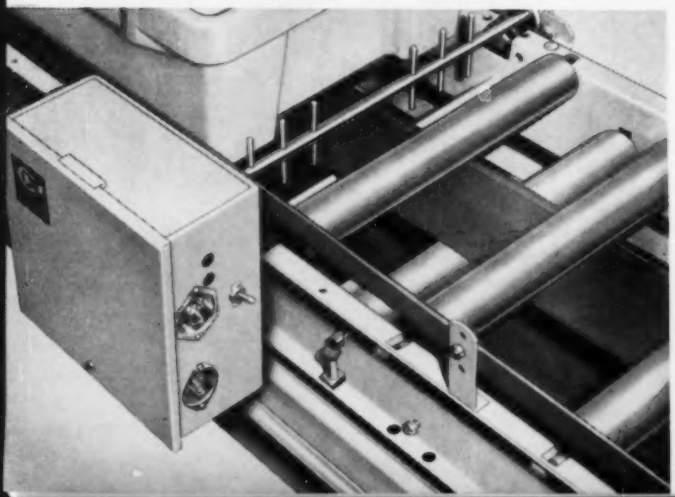
FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK AIRFLEX
INDUSTRIAL CLUTCHES AND BRAKES

Circle 692 on Page 117

"Skate wheel" diverters increase rate of flow and eliminate mechanical damage often caused by swinging metal arm diverters. Controller—designed with mechanical spring linkage to eliminate solenoid burnouts—may be mounted to either side of conveyor.

"Paddle wheel" tray stop eliminates pneumatic system and can be used as a spacer, counter or with a timer to release trays at programmed intervals. Paddle, spring-held to bottom of each passing tray, is operated by force of the moving tray.



Proximity type sensing heads, transistorized and plug-in, will read without failure at $\frac{5}{16}$" to improve flow reliability. Passing reader cards disturb a field emitted by sensing head and produce output signals to control conveyor operation.

CONTROL

What's new in material handling control?

Make your conveyor system more efficient with these new diverters, proximity readers, stop-spacers.

These new Cutler-Hammer specialized components have been successfully applied in some of the most outstanding automated material handling systems in operation.

The "roller skate wheel" diverter, for example, can double conveyor capacity without increasing conveyor speed. By eliminating the space formerly required for swinging metal diverter arms, carrying capacity is increased . . . damage to tote pans from swinging diverters is eliminated.

Adding greatly increased flexibility, these new devices have proven their efficiency in the most demanding engineered systems. Now they're being made available to you for your special applications. Each of these components measures up to the same high quality standards you've gotten for so long from Cutler-Hammer limit switches, pushbuttons, motor starters and other control apparatus used on conveyor systems.

WHAT ELSE IS NEW AT CUTLER-HAMMER?

These new conveyor control devices are typical of the many improvements coming out of Cutler-Hammer's systems engineering experience. As new problems are tackled, new ideas for solutions mean more and more improved new products are developed. Why don't you call your Cutler-Hammer sales office soon for new ideas that can help you solve your material handling problems?

WHAT'S NEW? ASK . . .

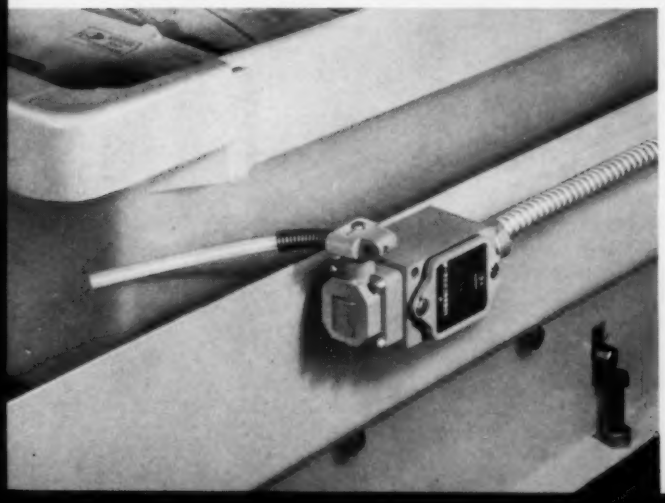
CUTLER-HAMMER

CONTROL

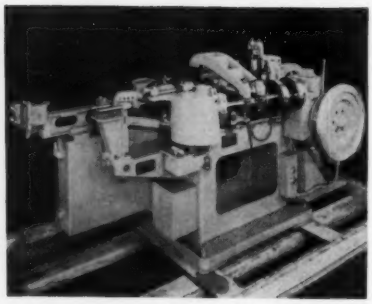
Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Cutler-Hammer Canada, Ltd.; Cutler-Hammer Mexicana, S. A.

Circle 693 on Page 117

Limit switches. Many operator options to fit your particular need. New spring mounted nylon operator can be mounted on side of conveyor and is actuated by passing trays. Special design is tamper proof and eliminates multiple counts.



Graphic control consoles can be engineered to fit your application. This one is main console for a 6,000 ft. order-picking system. Anodized aluminum conveyor layout has control switches mounted to facilitate manual or semi-automatic operation.



SYMMETRICAL HIGH-SPEED MULTI-SLIDE

Model MS-28-HS multi-slide is designed to reduce the piece part cost of formed stampings. Unit features symmetrical design. Die heads are reversible and can be used from either front or back, giving the advantages of versatility both in operation and in the designing of tools. Length of feed is 8 inches. Maximum width of stock is 1½ inches; and maximum thickness is approximately 1/16 inch. Standard equipment includes one complete die head with cam; back plate; tie bar; four high-speed forming slides with cams; stripper mechanism with cam; high-speed, positive grip type feed; stock check; stock straightener; brake; automatic lubrication system; 5 hp variable speed drive with outputs from 80-400 strokes per minute. **U. S. Tool Co. Inc.** Ampere (East Orange), N. J.

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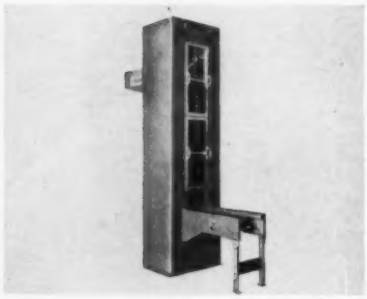

VERTICAL CONVEYOR DESIGNED FOR SINGLE OR MULTISTORY OPERATIONS

Continuous self-loading and unloading vertical conveyor, designated Verti-Matic, is designed for either single or multistory operations. Its automatic operation permits the unattended, vertical movement of case goods which individually enter the conveyor and come to rest on chain mounted flights. These flights convey the cases either up or down at speeds from 14 to 30 cases per minute. An infeed conveyor provides smooth, positive control in feeding cases into the conveyor. It permits any number of cases to be accumulated before entry. This vertical conveyor can be integrated into an existing conveyor system or designed into a new system. It is particularly adaptable to a line of Custom Pak conveyor systems. **FMC Materials Handling Systems,** P. O. Box 552, Riverside 13, Calif.

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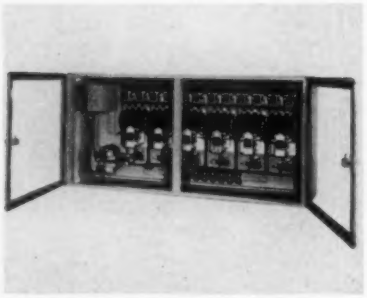

BRAKING CONTROL DESIGNED FOR USE IN TEXTILE INDUSTRY

Multiple-motor DynAC braking control for the textile industry's cloth inspection frames, looms, wrappers, and spinning frames is available in ratings up to 100 hp, 220 v and 200 hp, 440 v. It combines all starting and electrical braking functions of several motors within one enclosure and provides a complete dc electrical braking package for ac motors. A common dc power supply is used for braking of all motors involved. **Westinghouse Electric Corp.,** P. O. Box 2099, Pittsburgh 30, Pa.

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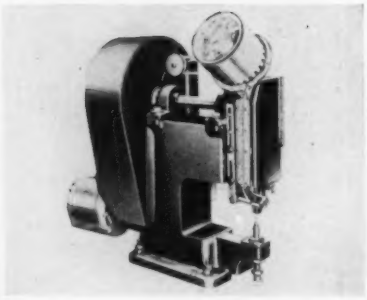

TUBULAR RIVET MACHINE HANDLES ALL MAKES OF RIVETS

High production heavy-duty tubular riveting machine is ideal for the electrical, electronic, and metal fabrication industries. In addition to tubular rivets, the ETCO 600 can also feed and fasten all makes of eyelets and grommets. No change in tooling is required to handle fasteners of varying lengths with the same barrel diameter. Adjustments for length and clinching are made by a simple screw setting of the anvil. Fasteners with different barrel diameters are accommodated by easily interchangeable feed tracks. The machine is capable of producing a setting force in excess of 3000 ft lb through its 40-lb flywheel. **Eyelet Tool Co. Inc.,** 31 Carleton St., Cambridge 42, Mass.

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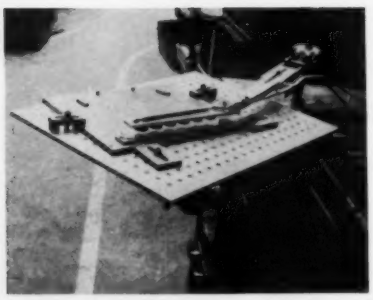

PRESS FEEDER FOR SINGLE PIECES

Electrically driven press feeder for single pieces is ideal for both very short and very long runs. It can be attached to any punch press. Workpieces are carried to the die by suction cups at an adjustable rate up to 3600 per hour. With this feeder the operator can increase production up to 100 per cent or more. Maximum weight of workpiece can be up to 5 lb. Features of the machine include very accurate transfer of parts with adjustable vertical lift from ¼ inch to 3 inches. Provision is made for use of a photoelectric cell to stop the press automatically if a part has not been ejected from the die. **Special Machinery Co.,** 199 Bay St., Toronto 1, Ont.

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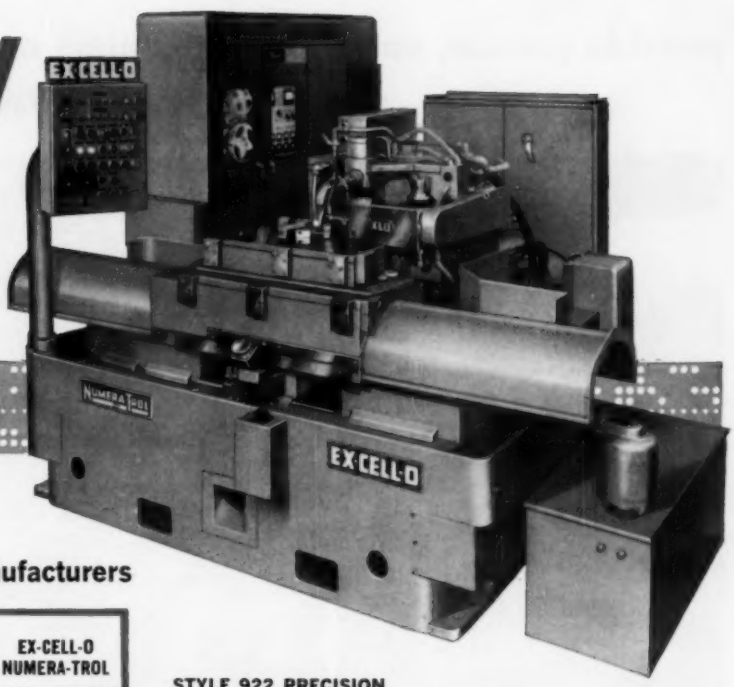
a study in time



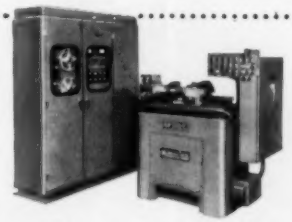
How Ex-Cell-O Numera-Trol Cuts Costs for Three Modern Manufacturers

Part: TEMPLETS	CONVENTIONAL METHODS	EX-CELL-O NUMERA-TROL
Lead time	128 hrs.	16 hrs.
Grinding per/piece	60 hrs.	6 hrs.
TIME SAVED	166 HOURS	

Part: FUEL CONTROL CAMS	CONVENTIONAL METHODS	EX-CELL-O NUMERA-TROL
Lead time	150 hrs.	40 hrs.
Machining per/piece	80 hrs.	7.5 hrs.
TIME SAVED	182.5 HOURS	

Part: STEAM TURBINE BUCKETS	CONVENTIONAL METHODS	EX-CELL-O NUMERA-TROL
Lead time	144 hrs.	24 hrs.
Machining per/piece	90 hrs.	12 hrs.
TIME SAVED	198 HOURS	

STYLE 922 PRECISION CONTOURING MACHINE
Slides are controllable to .000025". Grinding unit is interchangeable with boring and turning unit.



PRECISION CAM-MILLING MACHINE
Slashes lead time in producing drum-type cams.

PRECISION PROFILING MACHINE
Performs intricate and accurate milling and grinding of 3-dimensional forms.

Are you faced with tough prototypes or production parts that "can't" be produced economically? See your Ex-Cell-O Representative, or write direct for details on how you can apply Ex-Cell-O's Numera-Trol system of tape-controlled precision machine tools to do more jobs, faster and more accurately!

FREE—"A Guidebook to Numerically Controlled Machine Tools." Send for your copy today.

NUMERA-TROL (XLO)

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EX-CELL-O FOR PRECISION

PRECISION MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • JIG AND FIXTURE COMPONENTS • TORQUE ACTUATORS • CONTOUR PROJECTORS GAGES AND GAGING EQUIPMENT • GRANITE SURFACE PLATES • COMPUTER PRODUCTS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • ATOMIC ENERGY EQUIPMENT • DAIRY AND OTHER PACKAGING EQUIPMENT

Machinery Division

EX-CELL-O CORPORATION
DETROIT 32, MICHIGAN

Circle 694 on Page 117

CHROMALOX ELECTRIC HEATERS

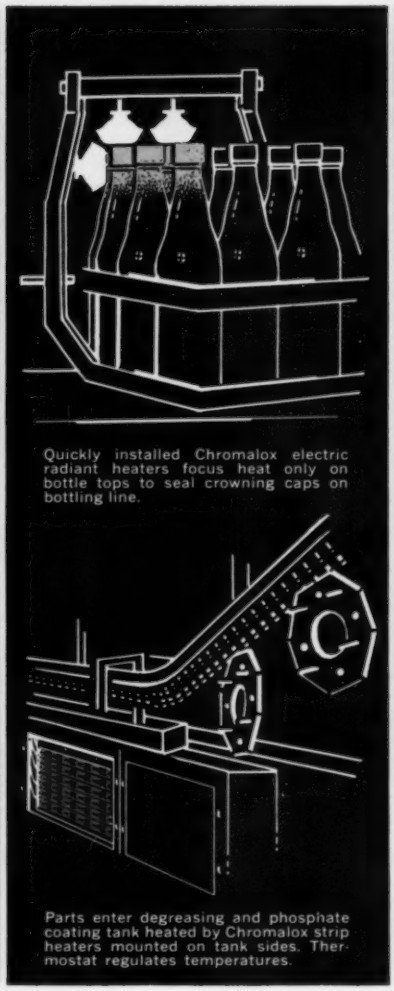
provide precise, uniform heat centers on automated operations, regardless of product size or shape

Precise control, from 4 to 100% of output, can be made an integral part of a Chromalox far-infrared heating installation. Temperatures are "dialed."

Compact far-infrared units interlock into self-forming ovens. Single or double heat sources in lengths from 24" to 185", many wattages.

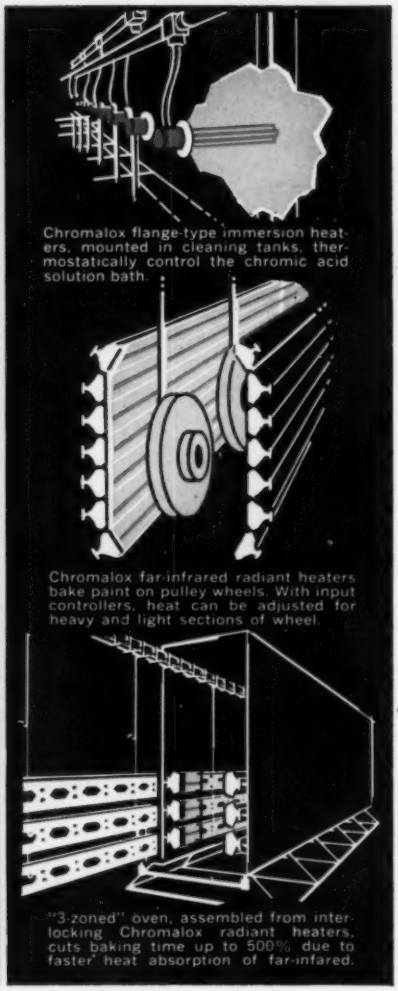
Straight lengths, formed or "finned" Chromalox strip heaters in 50 to 6,000 W; ¾", 1", 1½" widths; 5" to 96" lengths.

Chromalox immersion heaters — for heating water, oil and other liquids. 3" to 14" pipe flanges — with or without built-in thermostats.



Quickly installed Chromalox electric radiant heaters focus heat only on bottle tops to seal crowning caps on bottling line.

Parts enter degreasing and phosphate coating tank heated by Chromalox strip heaters mounted on tank sides. Thermostat regulates temperatures.



Chromalox flange-type immersion heaters, mounted in cleaning tanks, thermostatically control the chromic acid solution bath.

Chromalox far-infrared radiant heaters bake paint on pulley wheels. With input controllers, heat can be adjusted for heavy and light sections of wheel.

"3-zoned" oven, assembled from interlocking Chromalox radiant heaters, cuts baking time up to 500% due to faster heat absorption of far-infared.

Chromalox electric heating equipment can help you automate your production lines to cut costs, improve production and/or reduce rejects . . . as well as solve many of the critical heating problems encountered in line production. They are frequently used to boost existing heat-source temperatures. Among the Chromalox advantages are easy, low cost installation; dependable and economical operation; minimum attention and maintenance. Whatever your need for heat—whether for production-line or other processing applications—Chromalox electric heaters can provide exactly the heat source you require. Engineering assistance is available without obligation. Write, wire or phone.

FOR YOUR INFORMATION

Write for Catalog 60. It details uses for electric heat and describes thousands of types, sizes and ratings of Chromalox units.

EDWIN L. WIEGAND COMPANY
7746 THOMAS BLVD., PITTSBURGH 8, PA.
WI-24

CHROMALOX — FIRST NAME IN ELECTRIC HEAT

CHROMALOX ELECTRIC HEAT

PROCESS | COMFORT

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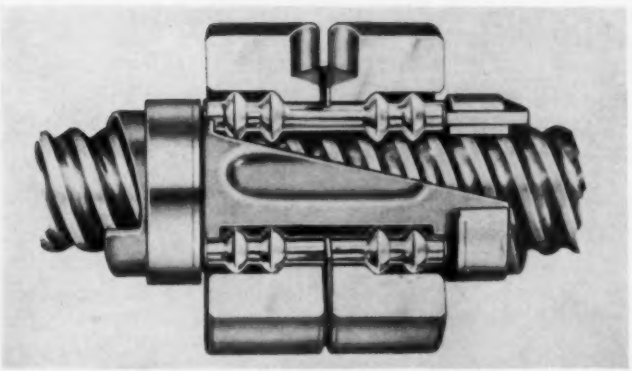
AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems.

For detailed information and literature, use card page 117



Bearing screw offers a planetary drive assembly for speed reduction or mechanical advantage and a positive drive assembly for accurate linear advancement and maximum efficiency. Both drives feature increased flexibility of design, high operating efficiency, economy of space and weight, and a long service life.

Antifriction Bearing Screw

LINEAR actuator, developed by **Roton Products Div., Anderson Co.,** Gary 40, Ind., converts rotary force and motion to linear force and motion—and vice versa—in a wide variety of actuating and positioning applications in both consumer and industrial fields. Included in these applications are machine tools, drafting tables, fused switches, pneumatic and hydraulic cylinder actuators, air traffic control systems, height adjustment mechanisms, reclining motor vehicle seats, and surgical and hospital furniture.

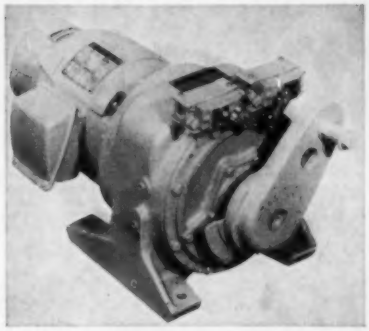
The device consists of a helical screw and a mating nut assembly. The nut assembly contains antifriction bearing units which are permanently spaced by a cage and contained by an annularly grooved nut that serves as the outer race. As the nut assembly and screw are rotated relative to each other, the bearings advance along the screw helix, transmitting power and motion.

Two types of drive assemblies are offered. A planetary type provides planetary action of the caged bearings around the screw which results in a mechanical reduction of linear advancement relative to the screw lead; this feature is available for mechanical advantage or speed reduction or both. A planetary drive features freewheeling motion at end of travel. The positive drive assembly is designed to produce constant positive linear advancement for those applications which require a fixed relationship between linear advancement and input revolutions. It is adaptable to multiple screw applications requiring synchronized advancements.

Circle 432 on Page 117

Electric Drive

Moduline motocylinders with Guardistor motors are designed for materials handling and other applications to replace air, hydraulic, or steam cylinders and to produce linear motion. A package includes a motor whose elements are connected in a control and warning system which removes the motor from the power source in the event of overtemperature. Basically, the motocylinder is a gear motor with a high-torque, high-slip, intermittent rated



electric Guardistor motor with an oversize magnetic disc-type brake. A crank is mounted on the output shaft and is machined to receive cams which actuate limit switches mounted on the upper part of the gear housing. The cams and limit switches can be adjusted to stop the crank pin at around-the-clock positions. Manual pushbutton controls or automatic timing controls can be used for starting purposes. The rapid accelerating and braking actions of the motocylinder enable the connected thrust rod to perform a wide

variety of functions. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

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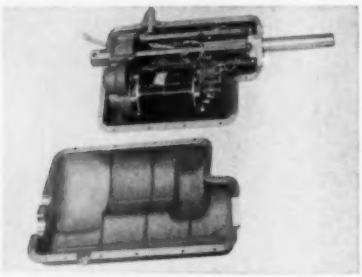

Linear Actuator

Featuring positioning accuracy repeatable to within ±0.0025 inch without feedback, Model C402 heavy duty linear actuator has a rated thrust of 500 pounds tension and compression, with a maximum thrust of 1000 pounds tension and compression. It has been designed specifically for the industrial market and has a continuously adjustable stroke of from 0 to 6 in. with an optional potentiometer for position indication, a capacitor start-and-run, and a reversible single-phase motor with integral brake. This actuator is entirely enclosed, and all ball bearings and gears are lubricated for life. Provision is made for emergency hand operation. **Electro-Mechanical Div., Lear Industrial Products, Lear Inc.**, 110 Ionia Ave., N.W., Grand Rapids 2, Mich.

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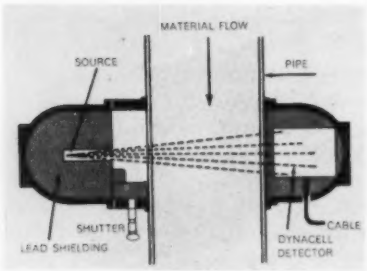

Process Systems

Qualicon series of liquid density gages provides continuous measurement of the density of a solution or slurry directly in a process pipe without contacting the material and without moving parts. Applications include: Solids control of coating solutions; water content of fruit concentrate; detection of pipe line interfaces; control of acid concentration; solids control of thickener underflow. Measurements accurate to within 0.0001 specific gravity units are attainable with these systems. The gages are designed for integration into existing plant processes without disruption of facilities or production. Measuring heads are available in two basic designs: The Duo-unit measuring head and the Mono-unit measuring head. These units permit installation on pipes or tanks ranging from 1 inch up as determined by the measurement requirement. **Nuclear-Chicago Corp.**, 333 E. Howard Ave., Des Plaines, Ill.

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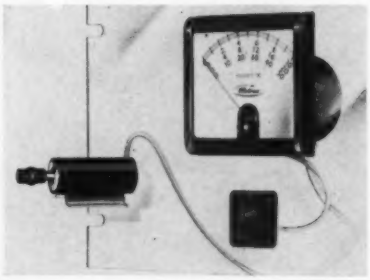

Fixed Tachometer

Panel-mounted fixed tachometer has been designed with three switch-selected ranges and a full-range accuracy of 1 per cent. It features high-visibility indicator, unit construction, and simplicity of installation. Panel mounting of the indicator requires approximately 4¾ by 4¼ inches of space, plus any convenient location for the range selector switch. The unit's pickup head may function as far as 1000 ft from the indicator unit which makes Model 47 ideal for installation in elevators, conveyors, or other materials handling equipment. A single-range model is also available which registers either rotating (in rpm) or belt speeds (ft per minute or inches per minute). Indicator scales are furnished accordingly. **Metron Instrument Co.**, 5300 S. Delaware, Littleton, Colo.

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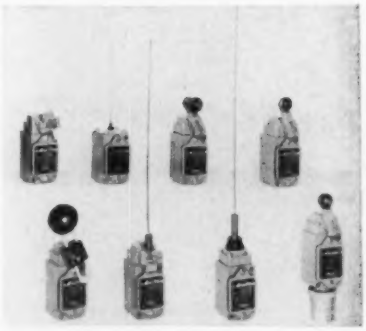

Limit Switches

Line of Type L precision oil tight limit switches feature new operators and optional features. Nine new switch operators and switches consist of: Roller lever with metal roller; roller lever with 1-inch wide roller; adjustable roller lever with 1½-inch diameter roller; adjustable spring rod actuator; adjustable nylon rod actuator; duplex limit switch; wobble stick with 12-inch wire extension; cat whisker operator; and precision adjusted roller lever available with either a metal or nylon roller. Five new optional features include a manifold style mounting; Joy receptacle, mounted and wired; wet limit switch; mounting adaptor kits; and oil tight conduit bushings. **Cutler-Hammer Inc.**, 315 N. 12th St., Milwaukee 1, Wis.

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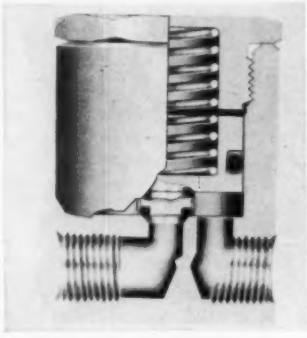

Priority Valve

Line of priority relief valves is capable of providing complete isolation of any portion of hydraulic or pneumatic systems below a preset point. The P-458 valve, operating at pressures to 2000 psi, is externally referenced with actuation accomplished by absolute system pressure. Fail safe valve closure is effected by posi-

Why Kearney & Trecker chose 8-channel punched tape input

The Kearney & Trecker Milwaukee-Matic is a remarkable tool even without numerical control. With NC, it's close to revolutionary. This automatic multi-machining center permits fast, economical small-lot manufacturing with minimum planning, far less lead time and dramatic reductions in tooling and inventory costs.

One major key to Milwaukee-Matic efficiency is the input. Kearney & Trecker picked 8-channel punched tape for reliability, durability, accuracy. And one thing more: ease of preparation on the Friden Flexowriter®. The Flexowriter has a standard typewriter keyboard. The operator (any competent typist) prepares a *visual* proof as she makes the tape. The machine parity-checks each code automatically. And finished tapes can be double-checked (or quickly duplicated) by running them back through the Flexowriter's reader.

Along with Kearney & Trecker, the great majority of machine tool manufacturers have already standardized on 8-channel punched tape input. Take it from them: punched tape is the best NC input. And in punched tape, Friden is the leader.

THIS IS PRACTIMATION: Friden is the world leader in tape technology and the practical application of the automation it makes possible. For full information, call your local Friden Systems Representative. Or write: Friden, Inc., San Leandro, California. ©1961 FRIDEN, INC.

Friden

Sales, Service and Instruction Throughout the U.S. and World

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tive spring pressure whenever downstream pressure drops below design closing pressure. The valve permits leakproof isolation of the upstream portion of a system at pressures below the set point to prevent the withdrawal of pressures to auxiliary systems beyond a point that would jeopardize proper functioning or safety of the primary system. Above preset pressure, valve is full open, permitting flow to downstream system with virtually zero drop. Valve body has ¼-inch female pipe connections. **Circle Seal Products Co. Inc.**, 2181 E. Foothill Blvd., Pasadena, Calif.

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Electromagnetic Brakes

Reverse - acting electromagnetic brakes have been developed for use on fractional horsepower motors and gear trains. They brake when de-energized and release when energized. Designated as BA-ER Series, these units are ideally suited for fail-safe operation. They are available in two sizes. Size 100 has a body diameter of 1-7/64 inches and a mounting flange diameter of 1-9/16 inches. It has a braking torque of 10 ounce-inches minimum and is rated at 2 watts power input. Size 130 has a body diameter of 1-9/16 inches and a mounting flange diameter of 2¼ inches. It has a braking torque of 30 ounce-inches and is rated at 3½ watts power input. Standard voltages (dc only) are 6, 12, 28, 48, and 100. Units for higher braking torque can be supplied. A user can preset the torque at which a brake will slip. **Dial Products Co.**, 19 Cottage St., Bayonne, N. J.

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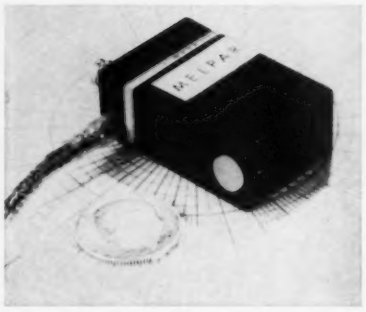

Photoelectric Reader

Approximately 2/3 of a cubic inch in volume, this highly sensitive miniaturized photoelectric reader combines a light source, lens, and photocell in a single unit. It was designed for use in automatic control systems using electronic circuits which operate as a function of reflected light. Model 150 may be used to insure proper position control and for counting and sorting items by color. At a distance of ⅛ inch from the lens, a resistance range of approximately 25,000 to 250,000 ohms is available with light reflection from white to black surfaces. Unique lens arrangement and packaging of the reader permit its use in limited-access areas where conventional readers, requiring two separate lenses, are impractical. Unit features good performance at reduced filament excitation. Range is flush to 1½ inch (resistance varies with distance). Response time is 4.0 milliseconds (for CL-3). **Melpar Inc.**, 3000 Arlington Blvd., Falls Church, Va.

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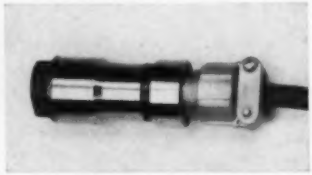

Pressure Transducers

Series of Ultradyne pressure transducers is designed to provide accurate measurements with ambient temperatures as high as 1000 F. Available as gage, absolute, and differential pressure measuring devices, the transducers provide nominal full-scale output of 200 millivolts with an accuracy of 2½ per cent over the temperature range from −65 to 1000 F. At room temperature accuracy is ½ per cent, and over any 250-degree span, 1 per cent. A symmetry-sensing circuit makes the output independent of line voltage and temperature variations. No pressure delay lines or intermediate hydraulic transmissions are required. Full-scale linearity is ±0.5 per cent. Resonant frequency varies from 200 to 2000 cycles per second, depending on pressure range. **Consolidated Controls Corp.**, Bethel, Conn.

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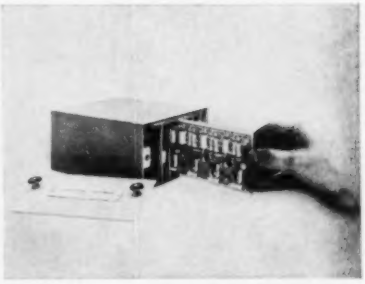

Remote Alarm Monitor

Solid state remote alarm monitor samples and encodes any number of data points and keys a single channel of any transmission medium. At the receiver, the signal is decoded and displayed. Operation is continuous. The Alertra Model 901 is suitable for operation over microwave, UHF, VHF, or any grade telephone line. Circuitry is completely transistorized. Construction is plug-in type. Rack or desk mounting is practical. **CompuDyne Corp.**, 687 S. Warminster Rd., Hatboro, Pa.

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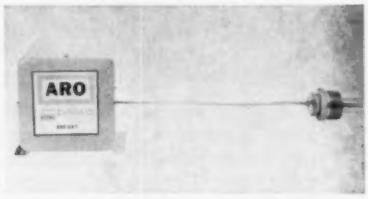

Liquid Level Control

Single sensor ultrasonic liquid level control is unaffected by foam, liquid viscosity, specific gravity or vibration. It will operate equally well in either conductive or non-

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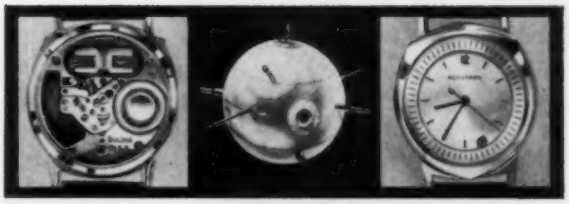
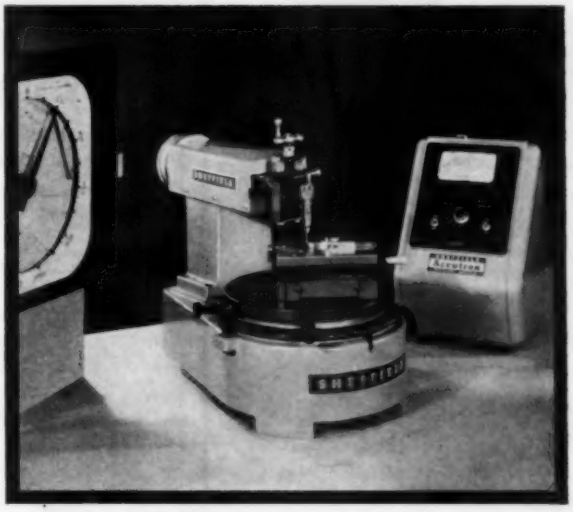
† TIME-KEEPING Great interest has been focused on the new Bulova ACCUTRON timepiece, a watch described by Bulova as "the first instrument of the space age you can wear and use! . . . It doesn't even tick. It hums! First timepiece guaranteed accurate on your wrist." "Accutron" is Bulova's trademark for timekeeping devices. It stands for new standards of accuracy.



® GAGING We welcome Bulova's use of the word "Accutron" as a compliment to the term already distinguished in the field of precision measurement. "Accutron," a Sheffield trademark for gaging devices, has long been a symbol of unquestioned accuracy and reliability. The Sheffield Accutron amplifier, for example, can show dimensions down to two and a half millionths of an inch, and is readily adaptable to an almost unlimited range of electronic gaging heads and tooling, for checking almost any dimension, shape, or relationship. Feathertouch gaging heads (with pressures as low as 5 grams) permit reliable measurements of soft or easily distorted parts. Accutron instruments are in constant service in Sheffield's own Eli Whitney Metrology Laboratory.

Your Sheffield representative can give you prompt competent technical assistance in any phase of your gaging needs. Write for the Sheffield catalog on ACCUTRON gages and accessories.



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"L" SERIES

A HIGH QUALITY LINE OF MALLEABLE HOUSED BEARING UNITS AND BEARINGS AT A COST THAT IS WARRANTED ON YOUR MACHINE!

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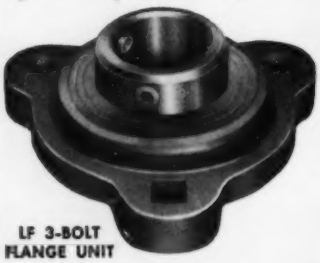

LF 3-BOLT FLANGE UNIT

Available in pillow blocks and two or three bolt flange units for flush or recessed mounting. All units in the "L" Series available with the new SEALMASTER contact type seal.

LP PILLOW BLOCK

LF FLANGE UNIT

LFT FLANGE UNIT

WRITE FOR BULLETIN 359

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A DIVISION OF
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PLANTS LOCATED IN: LOS ANGELES, CALIF. CLARKSDALE, MISS. • BELLEVILLE, ONTARIO

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conductive liquids and slurrys. The system features *On-Off* electrical ratio of 30:1, with adjustable sensitivity to provide repeatable accuracy of liquid level control to 0.005 inch over a broad range of liquid viscosities and operating temperatures. Models are available for use in the range from −425F up to 450F. Normally, two Sonac single sensor systems will be required for *On-Off* liquid flow control. The sensor is explosion proof. The safety factor in liquids under pressure is 2000 psi with 4:1 minimum burst. **Industrial Div., Aro Equipment Corp.**, Bryan, Ohio.

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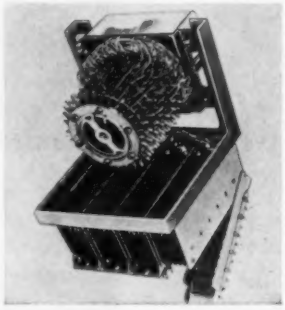

Rotary Stepping Switch

Compact unit switch is available completely wired to plug-in connectors. It provides 240 individual connections. Applications include programming, sequence control, routing, test equipment, impulse counter, memory device, and tallying and counting in production control. The switch features bridging-type wipers. Nonbridging wipers are also available. **Electronetics Div., North Electric Co.**, Galion, Ohio.

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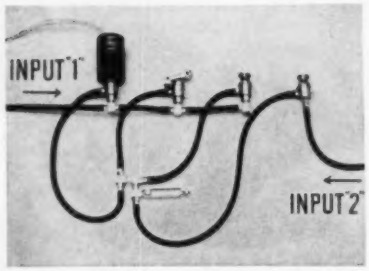
Shuttle Valve

Miniature shuttle or double check valve, has been designed for use in multiple fluid power circuits of cylinders, controls, and safety devices. Alternate flow from two inputs to a single output, but never to other input, is accomplished through use of a sliding piston with Buna-N seals. Exhaust is always through the input port where pressure was last applied. Photograph illustrates how



any number of these valves can be joined together to actuate one cylinder with valves controlled by solenoids, cam followers, or manual pushbuttons from one pressure source (Input 1), or different pressure sources (Input 2). These units are especially useful for inching operations, safety devices, or other multiple circuit applications where savings of space and weight are necessary. Valve has input ports tapped for 10-32 fittings. Working range is 0.5 to 250 psi. Air flow rate is 5 cfm at 50 psi. **Clippard Instrument Laboratory Inc.**, 7390 Colerain Rd., Cincinnati 39, Ohio.

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Liquid Rheostat

For use as an automatic load bank, current or voltage regulator, Model HDR-1(5) liquid rheostat supplies automatic operations from 5 to 100 kw in a 3 by 3 by 8-foot cubicle. Unit is a continuously adjustable resistance for use in high power, high current applications with either dc or ac service. Complete automatic control of stepless resistance range as well as variable sensitivity provides continuously adjustable power output. Control signals may be obtained from any number of process variables such as flow, temperature, or

AUTOMATION

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477-532—CATALOGS & LITERATURE—*page* 143

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401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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403 433 463 493 523 553 583 613 643 673 703 733 763 793 823 853
404 434 464 494 524 554 584 614 644 674 704 734 764 794 824 854
405 435 465 495 525 555 585 615 645 675 705 735 765 795 825 855
406 436 466 496 526 556 586 616 646 676 706 736 766 796 826 856
407 437 467 497 527 557 587 617 647 677 707 737 767 797 827 857
408 438 468 498 528 558 588 618 648 678 708 738 768 798 828 858
409 439 469 499 529 559 589 619 649 679 709 739 769 799 829 859
410 440 470 500 530 560 590 620 650 680 710 740 770 800 830 860
411 441 471 501 531 561 591 621 651 681 711 741 771 801 831 861
412 442 472 502 532 562 592 622 652 682 712 742 772 802 832 862
413 443 473 503 533 563 593 623 653 683 713 743 773 803 833 863
414 444 474 504 534 564 594 624 654 684 714 744 774 804 834 864
415 445 475 505 535 565 595 625 655 685 715 745 775 805 835 865
416 446 476 506 536 566 596 626 656 686 716 746 776 806 836 866
417 447 477 507 537 567 597 627 657 687 717 747 777 807 837 867
418 448 478 508 538 568 598 628 658 688 718 748 778 808 838 868
419 449 479 509 539 569 599 629 659 689 719 749 779 809 839 869
420 450 480 510 540 570 600 630 660 690 720 750 780 810 840 870
421 451 481 511 541 571 601 631 661 691 721 751 781 811 841 871
422 452 482 512 542 572 602 632 662 692 722 752 782 812 842 872
423 453 483 513 543 573 603 633 663 693 723 753 783 813 843 873
424 454 484 514 544 574 604 634 664 694 724 754 784 814 844 874
425 455 485 515 545 575 605 635 665 695 725 755 785 815 845 875
426 456 486 516 546 576 606 636 666 696 726 756 786 816 846 876
427 457 487 517 547 577 607 637 667 697 727 757 787 817 847 877
428 458 488 518 548 578 608 638 668 698 728 758 788 818 848 878
429 459 489 519 549 579 609 639 669 699 729 759 789 819 849 879
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402 432 462 492 522 552 582 612 642 672 702 732 762 792 822 852
403 433 463 493 523 553 583 613 643 673 703 733 763 793 823 853
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413 443 473 503 533 563 593 623 653 683 713 743 773 803 833 863
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427 457 487 517 547 577 607 637 667 697 727 757 787 817 847 877
428 458 488 518 548 578 608 638 668 698 728 758 788 818 848 878
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pressure. Unit is supplied either single or three phase with required control system to suit application. **U. S. Controls Inc.**, 410 Fourth Ave., Brooklyn 15, N. Y.

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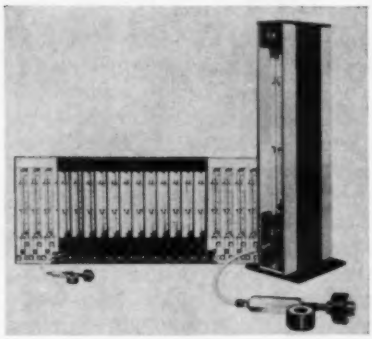

Air Gage

This gage can be used in bench-type operations and as a component of automatic inspection systems. A number of these units can be grouped easily and compactly into multiple systems that can be expanded at will. Four ranges of amplification are provided with 10-inch linear scales. A complete line of tooling is available for gage use. Tubes are spring loaded for ease of change. Individual columns are designed so that spare tubes and scales can be stored within the case. **Industrial & Automation Div., Radio Corp. of America**, 12605 Arnold Ave., Detroit 39, Mich.

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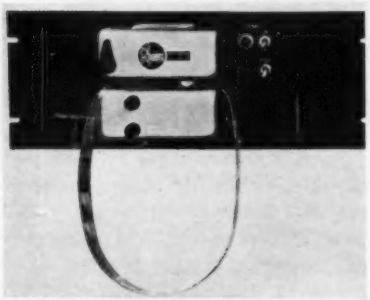

Photocell Reader

Device is capable of reading punched tape at the rate of 300 characters a second. It is ideal for many applications, including data processing and process control. Model RR-300 includes output amplifiers for all tape channels. Light shining on a solar cell is converted to current which is amplified within the unit. Reader is completely transistorized for long life and available as either a desk top or a rack mounted unit. Sensing element is one piece of silicon containing eight information and one timing track channels. **Electronics Div., Rheem Mfg. Co.**, 5200 W. 104th St., Los Angeles, Calif.

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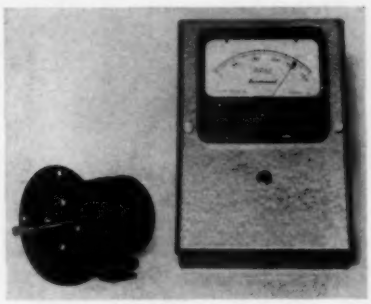


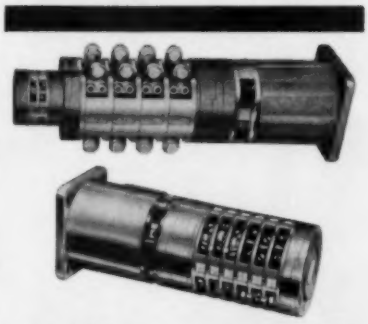
Tachometer Systems

Line of tachometer indicating systems utilizes instrument-type dc generators with permanent magnet fields. Precision indicating meters are used in conjunction with the generators to indicate speed of motor rotation and/or process variables. The permanent magnet field generator is supplied with both base and flange mounted arrangements so that it may be mounted to a motor by either direct shaft coupling or by pulley arrangement as best suited to an application. Unique circuit arrangements can be provided in various configurations to allow for expanded low speed with suppressed high speed scales; expanded low speed scale for one direction and automatic selection of full speed scale in the other direction; automatic multiscale selection systems as well as suppressed zero scale systems with expanded upper scale range. **Servospeed Div., Electro-Devices Inc.**, P. O. Box 2308, Paterson 23, N. J.

Circle 449 on Page 117

Electronic Timer

Electronic timer has an accuracy of 0.01 per cent and a time delay range of from 50 milliseconds to infinity. It utilizes crystal con-



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—eliminates relays, contactors, and interlocks

These drive-switch combinations are compact, and fully dependable. Available in ratings from 20 to 200 amps, 600 VAC. Up to 140 HP. As many as 74 contacts can be controlled at the lower ratings.

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Circle 699 on Page 117

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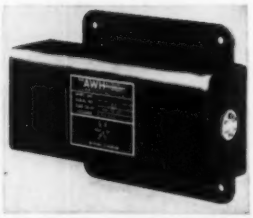

trolled binary count-down circuits for either single or multiple delays. The unit employs high quality aged components to assure stability of operation, while blocking diodes are incorporated to prevent damage to the timer if polarity is reversed. Standard versions are energized to time, and de-energized to reset. Reverse acting versions are pulsed to start, and automatically reset, while make-ready versions are energized to make ready, de-energized to time, and pulsed to reset. Contact arrangements range from single-pole single-throw to four-pole double-throw. Life is given as 100,000 operations at the rated contact load, while reset time can be only 25 milliseconds. Input voltage is 24-30 volts dc, while power required is 5.75 watts maximum. **A. W. Haydon Co.**, Culver City, Calif.

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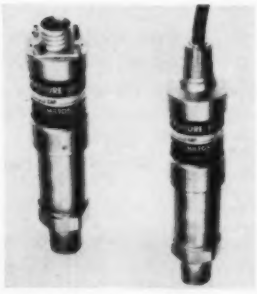

Pressure Cell

General purpose pressure cell for precisely measuring fluid pressures in a wide range of applications provides a combination of inherent high accuracy, rugged construction, long-term stability, infinite resolution, and high output signal. Fully active four-arm Wheatstone bridge provides an output sensitivity of 3 mv/v at relatively low stress levels. Direct bonding of gages to pressure-sensing element eliminates loss of accuracy between the pressure media and the sensing element, and assures low sensitivity to shock and vibration. Unit is available in 11

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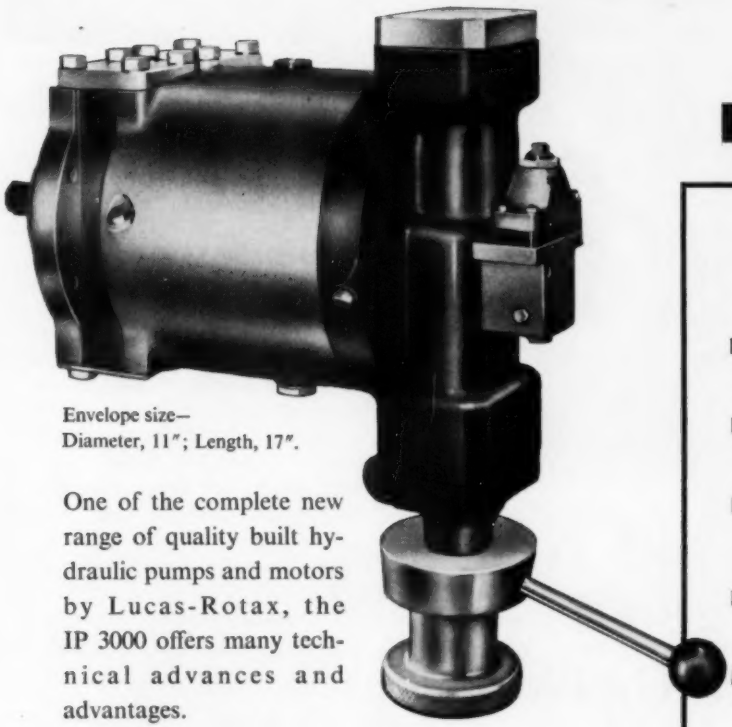

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- **Low cost**
- **High efficiency**
- **Fitted with pressure compensator as standard equipment**

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PUMP DETAIL

	Basic Pump Fixed Stroke
Fluid displacement (cub. ins./rev.)	13.89
Nominal working pressure (peak)	5000
(lb. per sq. in) (continuous)	3000
Nominal speed (peak)	2000
(r.p.m.) (continuous)	1800
Input h.p. at 1,000 r.p.m. and 1,000 lb. per sq. in. differential	38
Max. Torque (lb./ft.) per 1,000 lb. per sq. in. fluid pressure differential	200
Recommended Inlet Pressure (p.s.i.g.)	60
Weight (lb.) Basic Pump	128
Operating temperature	−40 to 200°F

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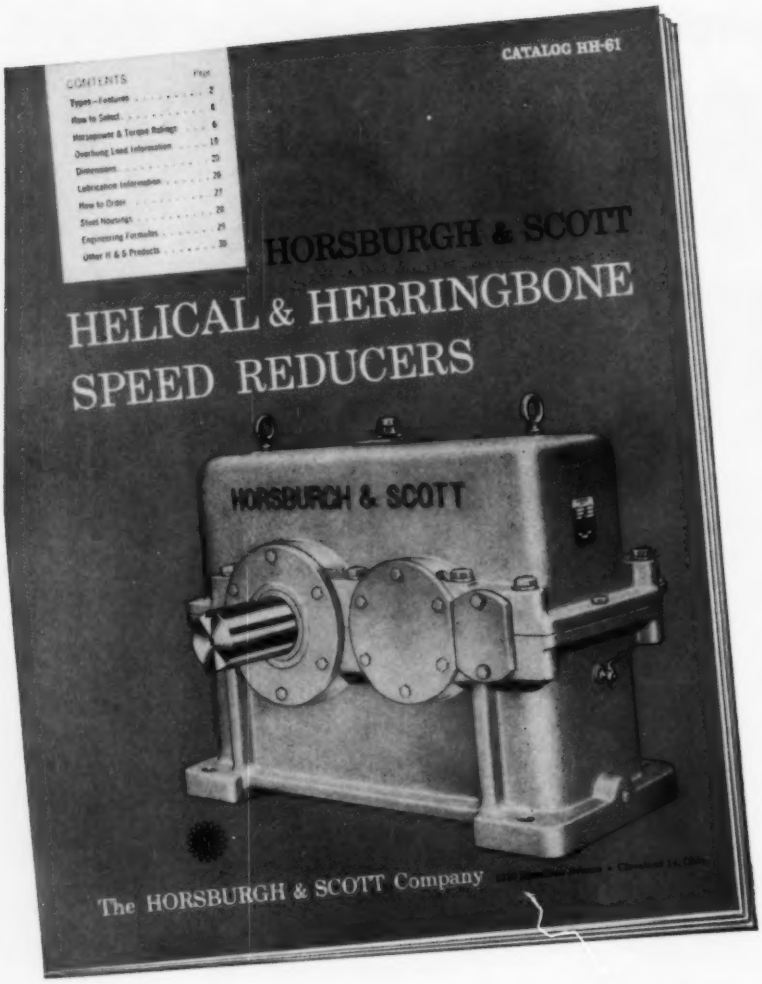

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Circle 702 on Page 117

capacities from 0 to 100 psi through 0 to 10,000 psi. **Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp.,** 42 Fourth Ave., Waltham 54, Mass.

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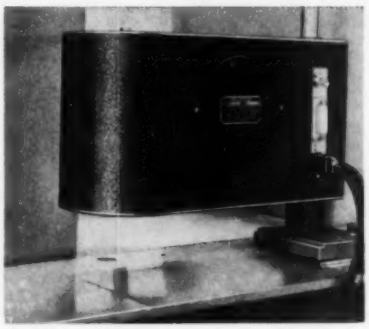


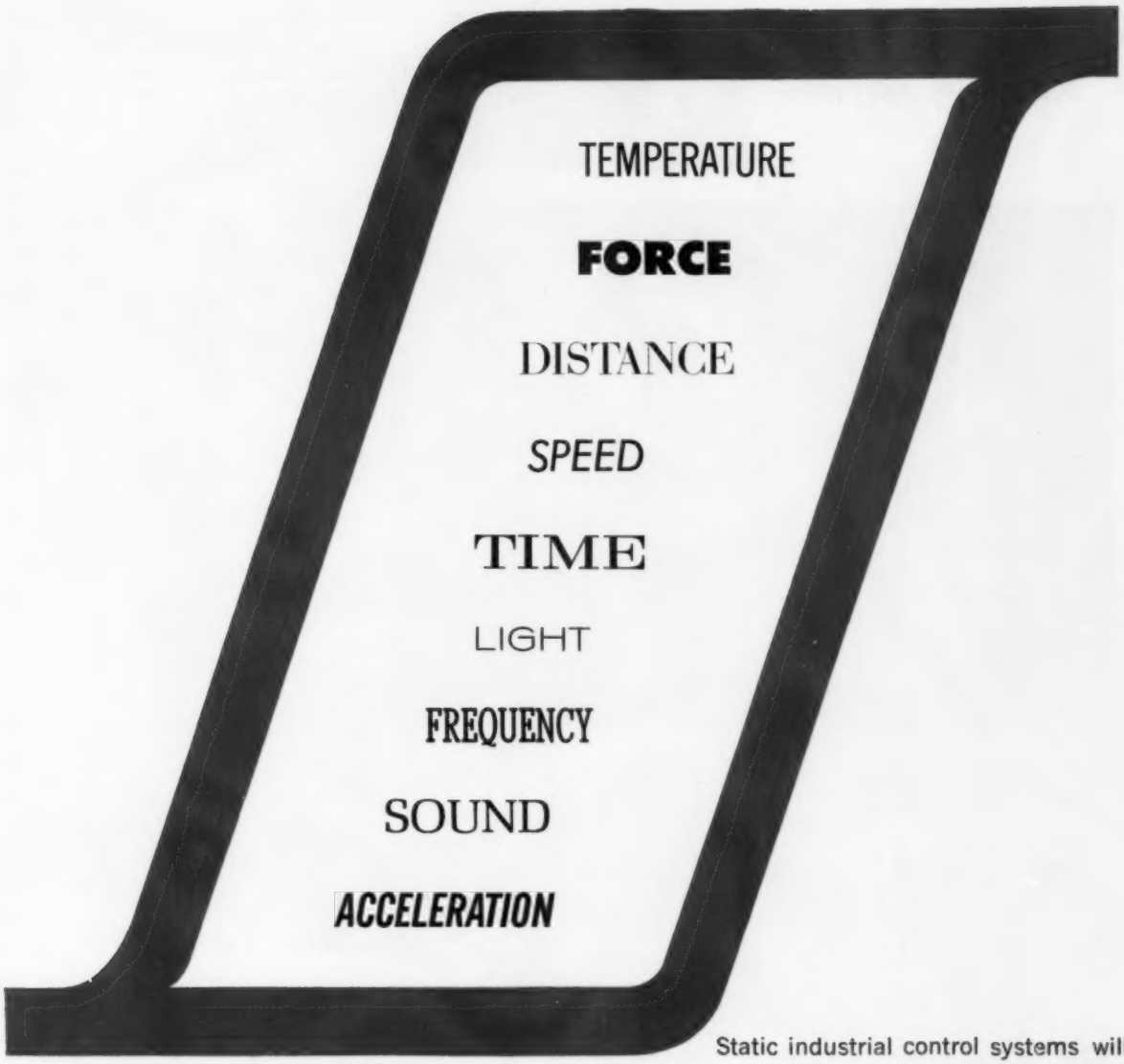
Box Numbering Machine

Numbering device is used for automatic consecutive numbering of conveyed boxes and shipping cases. It can be used on boxes as small as 4 inches long by $6\frac{1}{8}$ inches high, with no limit on maximum size. The machine incorporates up to 6 rotary printing wheels in a barrel-type head for numbering boxes consecutively from 1 to 999,999 and is available with either $\frac{3}{4}$ or 1-inch numerals. It adjusts vertically to permit locating numbers at any level on the box above approximately $3\frac{1}{4}$ inch from bottom. **Adolph Gottscho Inc.,** Hillside 5, N. J.

Circle 452 on Page 117

Shaft Angle Encoder

Noncontacting Gray code magnetic encoder, designated BuOrd size 18, synchro mount, provides accurate readout at 10,000 rpm and has low starting and running torques. It has a nonambiguous code and is mechanically interchangeable

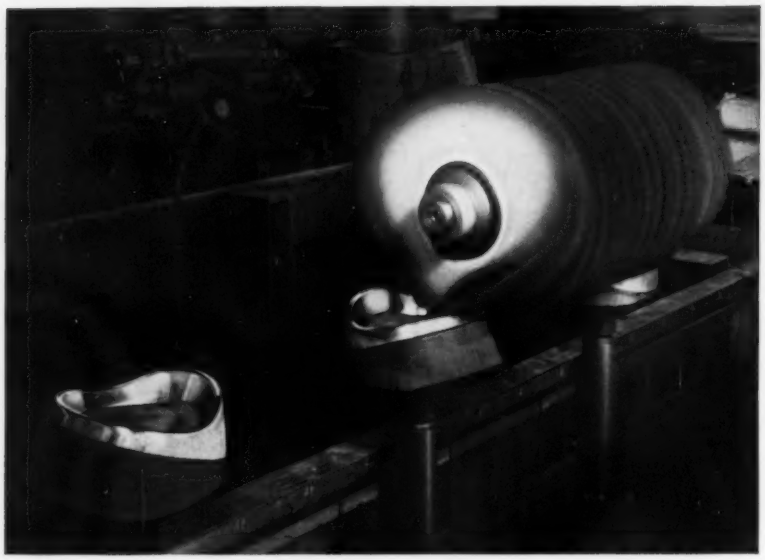


Static industrial control systems will regulate virtually anything that is controllable — and under normal operation these *magnetic* systems will never break down, wear out or need servicing. Temperature (with precision to ±1/4°F at 2200°), position (with logic involving *and, or, not, memory* and *time delay),* speed, force, light, sound, acceleration, frequency, distance, field strength and pressure are but a few. ■ One manufacturer has replaced a vacuum tube-mechanical relay system on his high-speed assembly lines. Reason: it broke down every three weeks. The replacement magnetic static control system has now gone through 26,000,000 consecutive cycles without fault. ■ The symbol above, the magnetic hysteresis loop, , may encompass some of your control problems which are solvable at a lower overall cost. May we discuss this with you? Magnetics Inc., Department **A-93,** Butler, Pennsylvania.

INDUSTRIAL CONTROL EQUIPMENT

MAGNETICS inc.®

ACME IN ACTION



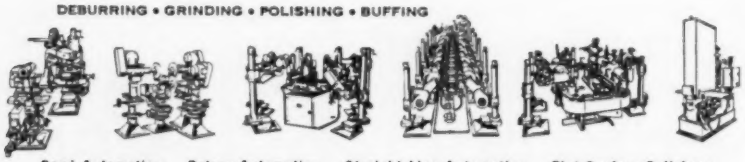
Doing more work with *Movement and Motion*

Good example of versatility in quality finishing equipment is the Acme Automatic Straight-Line Machine shown in action above. It's the "universal" type—one of many basic modular unit designs pioneered by Acme during the past 50 years to do more work better with movement and motion.

Made of standard sections assembled to any length desired, it can incorporate any number and combination of standard adjustable Acme heads designed to perform a variety of operations on a wide range of parts. Deburr, grind, polish and buff. Work-holding fixtures can be arranged for automatic lock and unlock. And the parts themselves can be run in a fixed position, rotated in one or both directions, or cammed as may be required to finish specific areas, assure ultimate uniformity of product quality.

Other types of Acme automatic straight-line polishing and buffing machines include Reciprocating, Fixture-Return, Horizontal-Return, Over-and-Under, Rotary and Rectangular. Send for complete information today!

DEBURRING • GRINDING • POLISHING • BUFFING



Semi-Automatics Rotary Automatics Straight Line Automatics Flat Surface Polishers

Comprehensive catalogs available upon request. Write, wire or call:

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Leading Producers of Automatic Polishing, Buffing and Deburring Machines Since 1910

Circle 703 on Page 117

with existing brush type encoders. Possible installations include utilization where long use, speed, and environmental conditions cannot be met by brush type encoders; for servo and shaft position encoding for slow-to-medium resolution; and for single turn and high resolution multiturn applications. Optional advantages include clockwise or counterclockwise rotation for increasing count and output circuitry to match input requirements of specific logic circuits. **Norden Div., United Aircraft Corp.**, Norwalk, Conn.

Circle 453 on Page 117

Relief Valve

Equipped with a polyvinyl chloride body for corrosive fluid handling applications, this relief valve is resistive to corrosive attack of acids, alkalis, salt solution, alcohol, and many other chemicals. Model 1911 is produced in sizes up to 2 inches and can be used at temperatures to approximately 160 F and adjustable pressures to 120 psi. Reduced pressure ranges are 5-15, 10-80, and 50-120 psi. Spring-loaded, diaphragm actuated, single seat valve modulates in response to upstream pressure. **Atlas Valve Co.**, 280 South St., Newark 5, N. J.

Circle 454 on Page 117

Workholding Jig

Self-centering workholding jig operates from shop airline. Designated Sure-Center, it is ideal for drilling, tapping, milling, counterboring, and reaming on round, hex,

NEW McGILL® SEALED CAGEROL® BEARINGS

specially designed
...to extend bearing life

Integral seals which retain lubricant and keep contamination out of critical bearing areas insure the superior performance expected with McGill's exclusive design advantages. Sealed CAGEROL needle bearings are ideal where auxiliary sealing is cumbersome and expensive and are especially serviceable where relubrication is impractical.

The combination of sealing and positive roller control produces a new standard of service life. Other CAGEROL design features include crowned rollers to prevent "end-loading" and black ferrous oxide retainer finish to absorb and retain lubricant.

CAGEROL bearings offer definite performance superiority where shaft misalignment and speeds exceed the limitations of ordinary end-guided needle bearings. Often up to 10 times more life can be expected. Interchangeable with ordinary needle bearings. Also available in unsealed series

Specify CAGEROL bearings to improve your machine performance.

Tapered retainer pockets assure proper roller guidance. Designed so retainer OD falls outside roller pitch circle to establish roller and crossbar contact on a concentric plane below center. This insures balanced roller support and eliminates corner wear from edge loading inherent in other designs.

For data on the complete line of McGILL heavy duty needle roller bearings, send for bearing catalog No. 62.

CONSULT McGILL EARLY
IN YOUR PRODUCT R and D
specialized engineering saves time, improves design

McGILL MANUFACTURING CO., INC.
Bearing Division
401 N. Lafayette St., Valparaiso, Ind.

engineered electrical products
McGILL®
precision needle roller bearings

Circle 704 on Page 117

ELIMINATE THOSE PROBLEMS—reduce maintenance and down-time—step-up production and solve the problem of costly repairs and replacement of air tools.

Compact package unit solves all three problems simultaneously.

- Regulates
- Lubricates
- Filters

Easily installed — only 2 connections

AIR EQUIPMENT and tools give top performance when the "working" air stream is
accurately regulated
efficiently lubricated
and free of dirt, grit, scale and water.

REGULATOR

BALANCED PISTON regulator maintains accurate regulation—balances air surges —automatic bleed-off. — long trouble-free service.

FILTER

DUAL FILTERING—CYCLONIC action—clean uncontaminated air—eliminates costly repairs, maintenance and replacement of air tools due to dirty air. Less down-time.

LUBRICATOR

AUTOMATIC FOG MIST lubrication prevents rusting and scoring—reduces costly repairs and replacement of air tools. Won't flood.

PSC complete line of single and combination controls listed in Bulletin 80. Send for copy today.

QUICK DISCONNECTS

The fast, easy operating PSC Disconnects permit quick, economical making and changing set-ups. **Less down-time—more production time.**

Ask for **BULLETIN 1475** and get complete details and engineering data on PSC Disconnects.

PERFECTING SERVICE CO.
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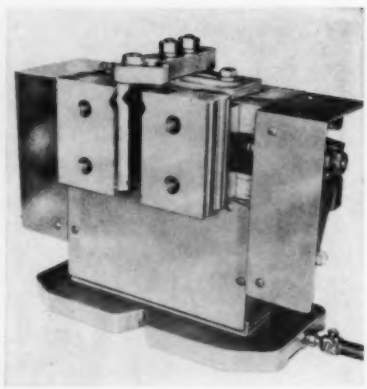
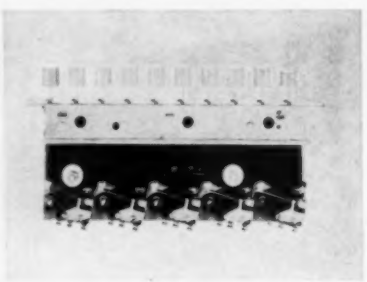
Circle 705 on Page 117



or square stock; standard or odd-shaped; smooth or rough castings. The jig's air vise consists of two movable gibbed master jaws, working from levers connected to an accurate cam which will repeatedly center a piece part within 0.0015 inch or better. The jaws can be set to drill the mean off-center, as well as for accurate center drilling. Holding force is over 5500 lb at 100 psi line pressure. Maximum jaw opening is 2½ inches. **Heuser Mfg. Co.**, 1638 N. Paulina St., Chicago 22, Ill.

Circle 455 on Page 117



Bar Switch

Parity code bar switch provides odd or even parity in the output code. Output is a five-bit code. The switch provides octal or decimal input and binary coded output. Conversion from an octal or decimal digit to binary code is performed by binary-coded contact closures. Full ten-button decimal banks with 1-2-4-8 binary output contacts plus parity are available in the DP series. The OP octal series has seven-button banks with 1-2-4 binary output contacts plus parity. Variations to specifications are available in both series. Binary coded outputs are limit switch contact closures with double throw contact arrangements coupled to the zero through nine or zero through seven pushbuttons. The switches are designed to permit stacking to form complete keyboards. **Computer Control Co. Inc.**, 2251 Barry Ave., Los Angeles 64, Calif.

Circle 456 on Page 117

Current Transmitter

Direct current transmitter measures direct current and transmits pneumatically to a central receiver. It is recommended for applications involving direct currents having values in the tens or hundreds of thousands of amperes such as are encountered in the electrolytic refining, plating, aluminum reduction, and electrolysis of sodium chloride in chlorine manufacturing. There is no contact of any kind between the transmitter and the current-carrying member. Accuracy is maintained to ±0.5 per cent of maximum current value. While maximum current is unlimited, minimum current for full-scale measurement is 0-5000 amperes. Type 19A transmitter operates with complete safety in any atmosphere. **Foxboro Co.**, Foxboro, Mass.

Circle 457 on Page 117

Reset Timer

Cycl-Flex plug-in reset timer incorporates two new optional features. Timer setting by key lock limits setting of the timer to qualified personnel only. The key itself performs the dial setting. When removed, the desired time setting is automatically sealed in. A pilot light (top center of dial) is used to give immediate visual indication from a distance that the timer is timing. This same pilot may also

New Model

FRACTIONAL HORSEPOWER

DYNAMATIC AJUSTO-SPEDE® DRIVE

EATON DYNAMATIC

Steps up Reliability and Durability

New in design but a veteran of proven dependability, the Eaton-Dynamatic Fractional HP Ajusto-Spede Drive offers a compact, low cost solution to adjustable speed control problems. Improvements include:

- **Longer operating life**
- **More uniform cooling**
- **Less noise and vibration**
- **Lighter weight**
- **Compact design**

The Ajusto-Spede Drive offers advantages not found in other methods of control. It is low in cost and easily installed. It is an integral combination of AC constant speed induction motor, eddy-current couplings, and single tube, electronic control. Special control functions, such as acceleration, inching, threading, cascading of multiple units, follower operation, constant tension and clutch motor operation can be provided by remotely mounted electronic controls.

Ajusto-Spede Drives operate on standard 115/230 volt, single phase, 60 cycle or 220/440 volt, 3 phase, 60 cycle alternating current. No special power source is required. Available from the manufacturer or from your nearest Dynamatic Distributor in sizes of ¼, ½, and ¾ HP at 1600 RPM and ½, ¾, and 1 HP at 3200 RPM. Can be supplied with either of two types of electromagnetic friction brakes and integral speed reducer in a wide variety of gear ratios.

Send for Illustrated Descriptive Literature

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...Your partner in progress through research...

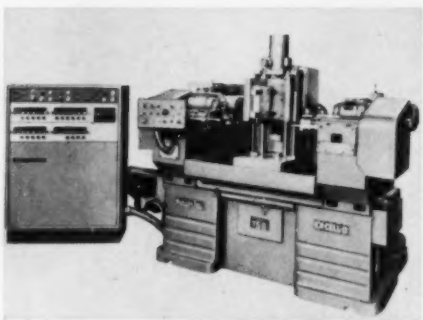
Circle 706 on Page 117

Rheem Electronics

NUMERICAL POSITIONING CONTROLS

Up to 6 Axes

Competitively Priced!



Rheem Numerical Control with Excello Model 758 Numera-trol boring machine.

VERSATILE

One system fits many machines ... offers savings in operator training, planning, maintenance.

- Modular construction by axis
- Different resolutions available
- High positioning speed
- Feed rate control available
- Large travel distances
- No stepping switches used
- Tape information distributed electronically
- Decimal display of tape information
- Virtually unlimited auxiliary functions
- Automatic, semi-automatic, and manual operation modes

■ Reduce lead time ■ Improve product quality ■ Eliminate expensive jigs and fixtures ■ Reduce scrap loss ■ Make small lots economical ■ Minimize inventory and re-run problems

Rheem Numerical Control with Burgmaster 25AHT turret drilling machine. Complete 2 or 3-axis systems available.

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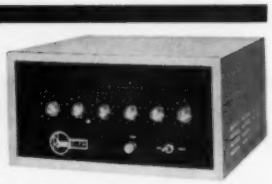
RHEEM POSITION DISPLAY



Designed to meet the requirements of operator controlled machines including retrofit on existing machines and inspection machines. Allows operator to position machine more rapidly and with greater accuracy, reduce operator fatigue, and avoid errors associated with reading of dials. For partial automation in both small and large shops. Available for one, two, or more axes of motion with typical resolutions of 0.001 or 0.0001 inches.

Rheem electronics

A division of Rheem Manufacturing Company

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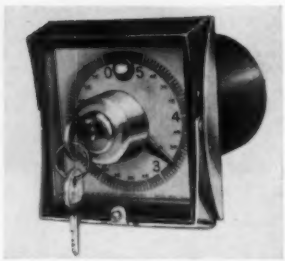
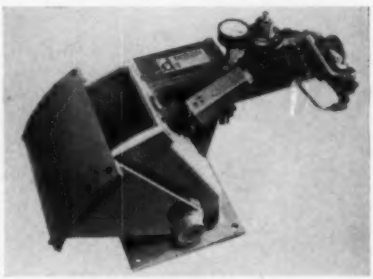
Circle 707 on Page 117



be installed by the supplier as an indication that the timer is resting in either the timed out or reset position. **Eagle Signal Co., Div., Gamewell Co.**, 202-20th St., Moline, Ill.

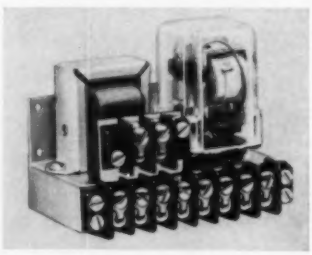
Circle 458 on Page 117



Flow Control Feeder

Swing-gate feeder for free flowing materials controls flow into automatic weighing systems or continuous process streams. It is available with either two-position full on-off control, or with modulated feed control to obtain full-flow to cutoff with modulated response. Feeder is self-cleaning and available in a wide range of flow rates. **Dynametrics Corp.**, Northwest Industrial Park, Burlington, Mass.

Circle 459 on Page 117



Photoelectric Scanner

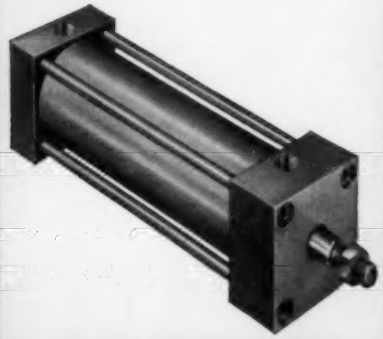
Requiring no tubes or transistors, Type PE-1 photoelectric scanner system provides positive response when the light-beam is interrupted

NEW FROM HANNIFIN

A GENERAL PURPOSE AIR CYLINDER

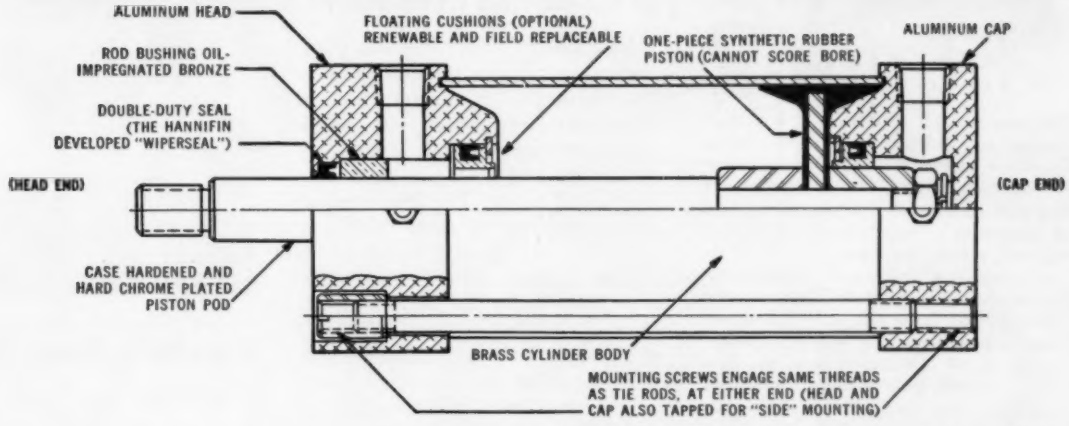
that gives you quality, low cost and mounting versatility

Hannifin announces a new design concept that gives you quality and economy in one package, the new Series "C" air power cylinder with . . .



- One compact basic design that provides side, cap end, or head end mounting without modification.
- Flange, foot or pivot mountings easily made with standard attachments.
- Rust proof construction — brass cylinder body, head and cap of aluminum.
- Cushions that do not change cylinder length — furnished as option or added in field with simple kit.
- An ingenious one-piece piston that cannot score the bore — of synthetic rubber, molded around a rugged steel disc.
- Piston rod both case hardened and hard chrome plated, polished to a fine finish for low friction and long seal life. Corrosion resistant.
- Rod bearing an oil-impregnated bronze bushing. Minimizes friction.
- Gland seal the Hannifin-developed "Wiperseal" — both a rod wiper and an efficient dynamic seal. It keeps air in, dirt out.
- 5 bore sizes — 1¼", 1½", 2½", 3¼" and 4½". Stock strokes from 1" to 20" in 1" increments.

This new Hannifin cylinder design is the latest of the complete Hannifin line of air power cylinders. To help you choose the best Hannifin cylinder for your application, talk to your nearby Parker-Hannifin man. He knows cylinders!


ALUMINUM HEAD
ROD BUSHING OIL-IMPREGNATED BRONZE
DOUBLE-DUTY SEAL (THE HANNIFIN DEVELOPED "WIPERSEAL")
FLOATING CUSHIONS (OPTIONAL) RENEWABLE AND FIELD REPLACEABLE
ONE-PIECE SYNTHETIC RUBBER PISTON (CANNOT SCORE BORE)
ALUMINUM CAP
(HEAD END)
(CAP END)
CASE HARDENED AND HARD CHROME PLATED PISTON ROD
BRASS CYLINDER BODY
MOUNTING SCREWS ENGAGE SAME THREADS AS TIE RODS, AT EITHER END (HEAD AND CAP ALSO TAPPED FOR "SIDE" MOUNTING)

PARKER HANNIFIN CORPORATION

PARKER-HANNIFIN

HANNIFIN COMPANY DIVISION

541 South Wolf Road • Des Plaines, Illinois

PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

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Circle 708 on Page 117

AIR-HYDRAULICS

NEW TABLE

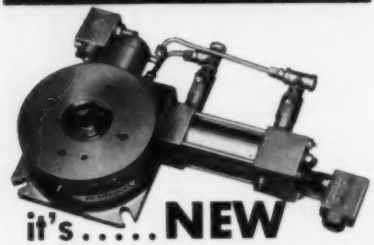
HANDLES UP TO
ONE TON

Index 30 positions per minute when equipped for 6 station operation with Air-Hydraulics' new Model 2400 (24" dia.) air index table • Handles work loads up to one ton • Bolt larger diameter plates to 1¼" ground steel table top for greater table area • Repetitive shock loads are no strain • 4" bore index cylinder develops power stroke 13 times line pressure for extra power and speed—no override • Adjustable cushion and speed control • Locking cylinder, mounted on table's centerline, means positive index every time— =.0015" • Limit switch keeps basic equipment from moving until table is "locked in" • Pressure lubrication, tapered roller bearing on shaft and ample bearing surface at circumference assure friction free operation • Operates on 60 to 175 psi line pressure • 4, 6, 8 or 12 stations with clockwise rotation standard • Others, including counterclockwise rotation, and from 3 to 60 positions to order.

WRITE NOW FOR CATALOG AND PRICE INFORMATION

AIR-HYDRAULICS

LOW COST
7" INDEX TABLE



it's.....NEW

The heavy duty Model 700 is only 7" in diameter but has most of the features found on larger models • Makes up to 75 indexes per minute • Handles maximum work load of 100 lbs. • Maximum power stroke is 3 times line pressure • Operates on pressures from 60 to 175 p.s.i. • Clockwise rotation with either 4, 6, 8 or 12 stations standard • Others up to 24 stations and counter-clockwise rotation, to order • Bolt larger sub-plate (up to 14" dia.) to ground steel table for larger work area • Positive index—no override • Adjustable cushion and speed control • Each table checked for guaranteed accuracy of index (± .0015"), concentricity and parallelism.

WRITE NOW FOR FREE CATALOG AND PRICE INFO.

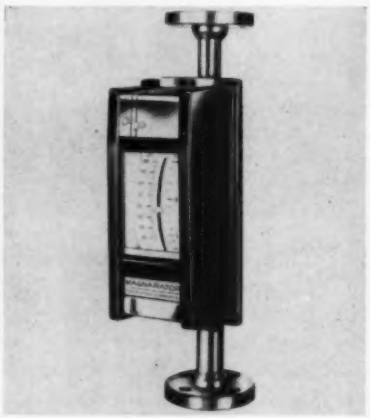
AIR-HYDRAULICS

299 HUPP AVE.
JACKSON, MICHIGAN

Circle 709 on Page 117

by objects as small as ¼ inch wide at counting rates up to 500 per minute. Depending on the light source and photocell used, operating ranges can be up to 8 feet. Using a power-type photocell with high infrared sensitivity and with a filter to minimize the effect of ambient visible light, the system operates a dc relay without need for amplifiers. It provides positive operation even on slow beam interruptions. The scanner is complete with 110-130 v, 50/60-cycle power unit, plug-in relay, and choice of miniature or medium-range scanning heads. **Farmer Electric Products Co. Inc.**, 2300 Washington St., Newton Lower Falls, Mass.

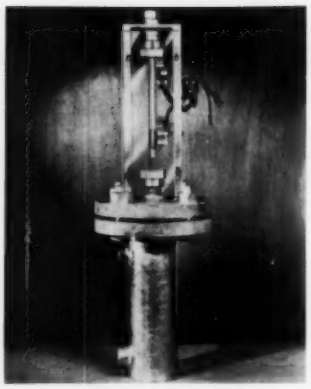
Circle 460 on Page 117



Transmitting Rotameter

Instrument, designated as Magnarator, combines the functions of an indicating rotameter and a pneumatic transmitter. It measures liquid or gas flows and is accurate to within 1 per cent over its 10 to 1 range. The single model transmitter can be used with any metering tube ½ to 2 inches in diameter covering flows equivalent to 1 to 100 gpm water and 4 to 400 scfm air. Transmitting rotameter is through-flow and eliminates the need for offset piping, spools, tees, purges, and bleeds. Steam jacketed and high pressure transmitter models and an extension design for use with meters larger than 2-inch pipe size are also available. **Fischer & Porter Co.**, 676 Jacksonville Rd., Warminster, Pa.

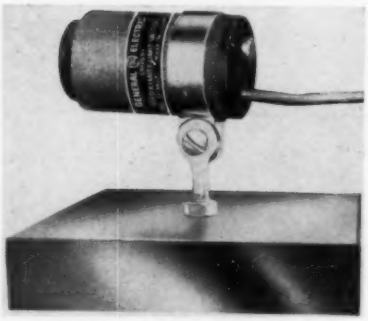
Circle 461 on Page 117



Liquid Level Gage

Liquid level indicating control is designed to provide trouble-free and accurate visual readout of liquid level variations in refrigerant vessels. It utilizes visual indication to provide information to the operator as to status and behavior of liquid in a vessel. Vessels can be open or pressure types. The Gage-O-Matic is manufactured to order, with single or multiple control switches to provide automatic operation of pumps, valves, indicator lights, alarm bells, compressor shutdown, and signal circuits to outside police protective organizations. It is capable of controlling any type of liquid, hot or cold, clear or colored. **H. H. McKinnies Co.**, 3131 W. Mill Rd., Milwaukee, Wis.

Circle 462 on Page 117



Proximity Limit Switch

Proximity limit switch, designed to detect any metal object without physical contact, will sense nonferrous materials up to ½ inch and ferrous material up to an inch away. All-transistorized circuitry (no vacuum tubes) is self-contained in the operating head of the CR115 D

Circle 710 on Page 117→

POST ELECTRONIC PRODUCTS and CONTROL SYSTEMS

PROVIDE:

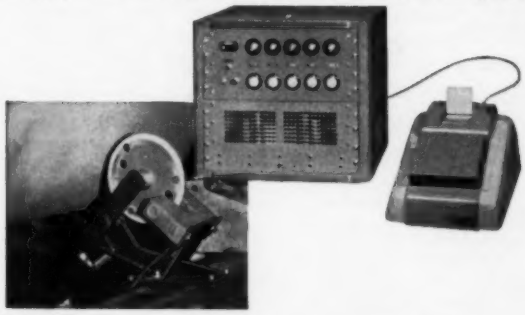
AUTOMATION • CONTROL • WATCH DOG RELIABILITY

WIDESPREAD ACCEPTANCE is the best evidence of Post's contributions to measurement, and production control. A great variety of problems can be solved by Post electronic products . . . from "batch" counting to paper break detection.

Why not "ASK POST" for an analysis of your particular problem. We will be happy to help you find a solution.

TYPICAL POST DEVELOPMENTS*...

FCB-1 High speed, automatic, small parts counter-batcher. Portable —Feeds, counts and batches small parts, tablets, hardware, etc.



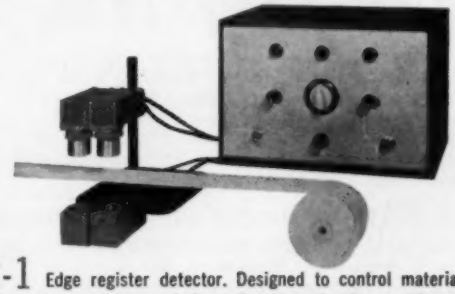
LF-1A Lineal footage measurement, electronically . . . Capable of length measuring continuous production items, i.e., paper, wire, rope, ribbon, etc.

Features visual and printed readout.

P2-RM A preset type counter capable of counting batches in any desired quantity 1-100 (inclusive) with a built-in, 2 scale, rate meter calibrated in "thousands per hour".

PDC The Post "difference" counter . . . capable of maintaining counts of two (or more) variables and acting to control exact difference, i.e., shafts running at different RPM where it's important to maintain "difference" ratio. Many other applications. Adds, subtracts and visually indicates condition.

PW-5 Shown in paper making application. The counter is connected to a lineal footage measuring unit which accurately records paper production. Also provided is a "paper break detector" which will instantly shut off the machine should a web break occur.



ER-1 Edge register detector. Designed to control materials manufactured or processed in a web form. Detects web edge position with extreme accuracy. Inward or outward displacement of web actuates photoelectric control relays for correction.

Get full details on Post equipment today. Check the coupon below.

**These are only a few of the many electronic counters and controls offered by...*

POST

ELECTRONIC PRODUCTS

Division of Reid Brothers Co., Inc.

17 LOTHROP STREET, BEVERLY, MASSACHUSETTS

Your special problems are earnestly requested!

Note: Complete line of production line counters available.

FCB-1	Please send me the following product literature.
LF-1A	
P2-RM	NAME
DFC	TITLE
PW-5	COMPANY
ER-1	ADDRESS
Please have a representative call	

SUNBEAM electric heater cases get uniform finish with RANSBURG electrostatic. . . . 6 times as many per gallon of paint—15 times faster.

"Paint Mileage Leaps 500%.... Production Upped 15 Times" Reports ENAMELED STEEL & SIGN CO.

Curt Simmons, President, ENAMELED STEEL & SIGN COMPANY of Chicago, describes results with RANSBURG Automatic No. 2 Process Electro-Spray: "We first painted cases for the new SUNBEAM portable electric heaters with air hand spray at the rate of 200 pieces per day using 6 gallons of paint. Now, with RANSBURG electrostatic we've increased production 1400% to 3000 pieces daily with only 15 gallons of paint." An increase of 500% in paint mileage! *What would savings like this mean in your finishing department?*

QUALITY IMPROVED WITH RANSBURG ELECTRO-SPRAY

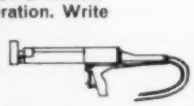
Sags and runs, a problem with the air hand spray, have been eliminated with the automatic electrostatic equipment. Mr. Simmons adds: "Now we achieve a uniformity over the configurated area which wasn't always possible before. We know the 50,000th piece will turn out the same as the first."

ENAMELED STEEL—sold on the efficiency and versatility of RANSBURG Electro-Spray—uses 14 automatic No. 2 Process units to meet the heavy demands of their diversified, high volume production.

NO REASON WHY YOU CAN'T DO IT TOO

Manufacturers—large and small—are reporting similar savings in paint and labor with increased production. If your volume doesn't justify automatic electrostatic equipment, perhaps the RANSBURG electrostatic hand gun will help cut costs in your finishing operation. Write for our new brochure showing actual in-plant production photos, savings figures and detailed information on RANSBURG No. 2 Process Electro-Spray.

RANSBURG



RANSBURG Electro-Coating Corp.

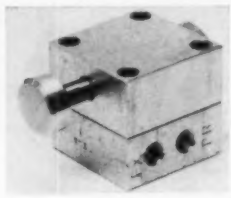
Box 23122, Indianapolis 23, Indiana

Affiliates in AUSTRALIA • AUSTRIA • BELGIUM • BRAZIL • DENMARK • ENGLAND • FRANCE • FINLAND GERMANY • HOLLAND • INDIA • IRELAND • ITALY • NEW ZEALAND • NORWAY • PAKISTAN • SOUTH AFRICA SPAIN • SWEDEN and SWITZERLAND

Circle 711 on Page 117

Switch. Sensing head of the switch will operate under water. Rated at 30 v dc, input; 30 v dc, 250 milliamperes, output, the switch has a maximum repetitive accuracy of 0.005 inch. Maximum differential is 0.01 inch; and operating time is 20 milliseconds. Switch is capable of operating in ambient temperatures up to 150 F. It may be used with either static control or magnetic devices. **General Electric Co.**, Schenectady 5, N. Y.

Circle 463 on Page 117



Gage Isolator

Designed to prevent gage damage from pressure surges in all types of hydraulic circuits, gage isolator is a normally-closed, spring-returned, three-way valve. Depressing a pushbutton opens the pressure line to the gage to permit reading. When the button is released, the gage is isolated from pressure and drained to the reservoir. This device acts as an effective snubber to prevent gage damage caused by pulsations, chatter, and fluid hammer. Gage isolators are available for operating pressures to 5000 psi and can be used with any hydraulic oil and other noncorrosive fluids. **Sarasota Precision Products Inc.**, 5757 McIntosh Rd., Sarasota, Fla.

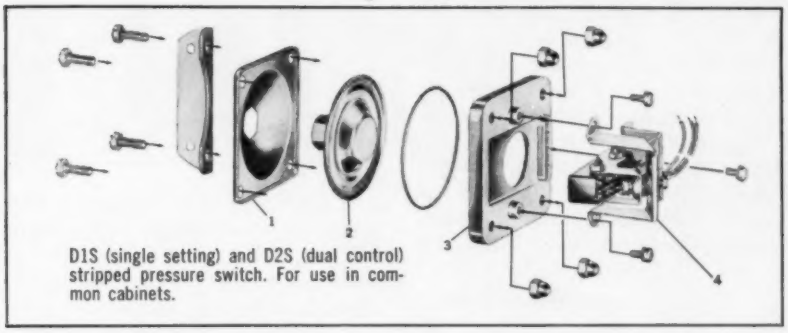
Circle 464 on Page 117

Rotary Indicators

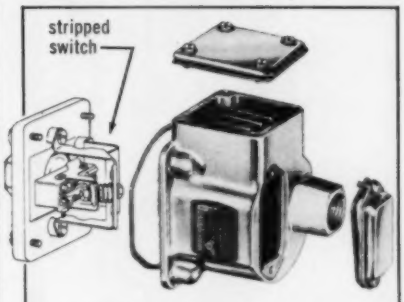
Microminiature rotary indicators which signal by means of a shutter arrangement, can be used as malfunction indicators, annunciators,

(Advertisement)

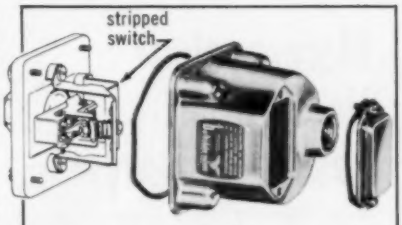
How to put 50% more accuracy into a pressure switch at 25% lower price



D1S (single setting) and D2S (dual control) stripped pressure switch. For use in common cabinets.



D1T (single setting) pressure switch with integral terminal block. Weatherproof housing.



D1H (single setting) and D2H (dual control) pressure switch with standard housing. Weatherproof.

The accepted standard of accuracy in pressure switches is ±1%. The new Barksdale diaphragm pressure switches are guaranteed for ±½% set and reset accuracy. This instrument accuracy, unique proof (test) pressure characteristics, and remarkably easy servicing are accomplished by the use of a "basic unit" diaphragm assembly to which components are attached as required. The erector set principle permits production economies that are reflected in substantially lower prices. The entire concept of Barksdale pressure switches is the result of desired specification improvements as suggested by representatives of varied industries who were consulted before designing was begun.

The versatile basic unit

A leakproof, welded-metal sensing element (No. 2 in the photograph above) is surrounded by a heavy protective capsule (Nos. 1 and 3) which is independent of the sensing and switching elements. The hex of the pressure connection fits into a hex opening in the base of the capsule, preventing damage to the diaphragm should the unit be twisted during installation or removal. The standard pressure connection is ¼" npt female pipe fitting; ½" npt fitting is available when specified. The latter was requested by the petroleum industry to facilitate removal of paraffin accumulation and to permit attachment of switches directly to ½" pipe.

Diaphragms easily removable

Diaphragms may be removed without disturbing switch wiring, thus making it possible to change diaphragms to accommodate varying pressure requirements or to substitute diaphragms of different metals as fluid characteristics may demand. This feature cuts inventory costs for original equipment manufacturers because they need stock only diaphragms to meet their various pressure requirements rather than to stock complete switches in every category. It is important, also, to the petroleum industry because only diaphragms (not entire switches) need be carried by personnel doing field service.

Proof (test) pressures to 300 psi

The upper and lower sections of the diaphragm capsule are molded to fit the sensing element exactly. The top section prevents the diaphragm from stretching beyond normal curvature when surges above system pressure are encountered, and there is no possibility of metal distortion that would affect switch accuracy. In the low settings the new Barksdale pressure switches will actuate at 0.1" mercury with proof (test) pressure to 10 psi. In higher ranges they will go up to 300 psi proof (test) pressure at settings to 150 psi.

Stripped switch (single and dual control)

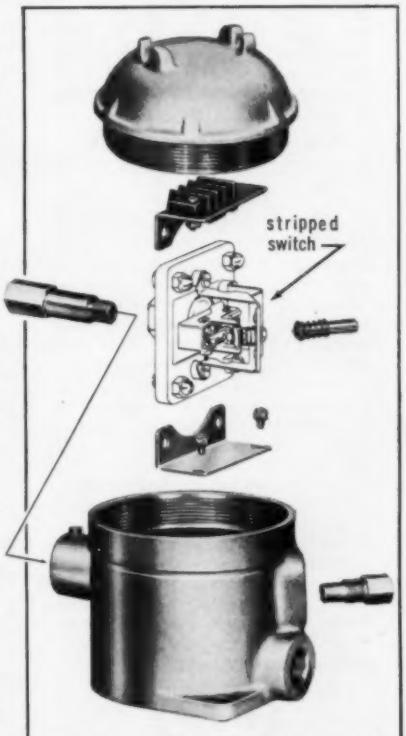
Addition of a switching element (No. 4 above) to the basic diaphragm unit makes a stripped switch for use in a common cabinet with other electrical devices. Original equipment manufacturers need not pay for unneeded housings. Extremely fine adjustment is possible because the adjusting screws have 64 threads to the inch. Adjustment may be made with a screwdriver or a wrench.

Housings added to suit

Addition of a sealed housing (standard, terminal block, or explosion proof) to a stripped switch completes a pressure switch that can be ordered "tailor made" for any desired application. In the standard housing, free wire leads are through a ½" nps conduit conductor. Wires are held firmly in place by a special tension clip that prevents disturbing the switch adjustment through careless wire handling. Terminal block housings are available for wiring convenience. Pottable electric outlets and external adjustment on explosion proof housings were suggested by the petroleum industry. Servicing instructions on all Barksdale switch housing are on the inside of a tamper proof cover to allow for painting of units.

Ask for new catalog

New Barksdale diaphragm pressure switches offer you something new in accuracy, proof (test) pressure, and economy. The just-printed catalog tells the complete story. Ask your Barksdale representative or write to Barksdale Valves, 5125 Alcoa Avenue, Los Angeles 58, California.



D1X (single setting) and D2X (dual control) explosion proof pressure switch. Pottable electric outlets. External adjustment.

Circle 712 on Page 117

More cycles! No stretch! Less punch wear!

New "Peerless" Fibre control tape wears 30 times longer than paper; costs 1/6th that of polyester film!

Need a tough tape that will take machine shop handling? A durable tape for repeat operations? Check the savings in new "Peerless" control tape. It's made of National Vulcanized Fibre, a cellulose plastic—the only tape of its kind!

Compare "Peerless" tape's long, cost-cutting cycle life:

Speed (CODES PER MINUTE)	Paper Tape (CYCLES)	"Peerless" (CYCLES)
1200	100 to 115	3,000 & over
620	1200 to 1900	30,000 & over

And check "Peerless" tape's amazing properties! It's extra tough, flexible, with high tensile and bending strength. It has high opacity, excellent abrasion resistance and is easily punched. Thicknesses: .0043" and .005"—heavier thicknesses available.

"Peerless" does not stretch in use. Precision-punched holes remain true. In addition, "Peerless" is *plastic-smooth* and impurity-free; friction and wear on punching and feeding equipment are cut to the minimum.

"Peerless" tape is available in any width. It is already proving its superior economies in tape life and cost on major automatic programming equipment in industry, government and business. Colors: Red, Gray, Blue, Black. Investigate now. Write for Free test sample and complete information. Dept. UU-9.

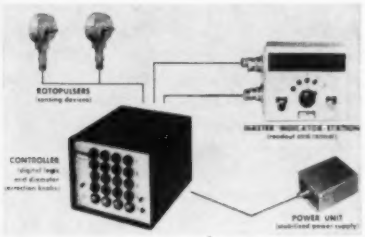
NVF

NATIONAL VULCANIZED FIBRE COMPANY
WILMINGTON 99, DELAWARE
In Canada: NATIONAL FIBRE CO. OF CANADA, LTD., Toronto 3, Ont.

Circle 713 on Page 117

binary readouts in computers, output indicators in transistor circuits, and for other applications where two-position indication is required. These indicators come in two sizes, the smaller of which measures 0.375 in. diameter by 0.562 in. long. The unit is designed to use 100 milliwatts or less and can be supplied for any standard voltage to 30 v dc or ac at 400 cps. It is also available for 110 v operation with an external resistor. Rotation can be up to 60 degrees in either direction. **Daco Instrument Co.**, Tillary & Prince St., Brooklyn 1, N. Y.

Circle 465 on Page 117



Digital Draw Indicators

Line of digital draw indicators is designed for precise draw or speed measurement on paper machines and other similar applications. The indicators measure draw or speed to 0.1 per cent accuracy at all operating speeds and require no calibration. They feature direct-reading rapid numerical indication of measurement in about ½ second and indicate positive or negative draw with a plus or minus sign. Two types are available. Type A units have a maximum capacity of 5 channels for measuring 5 draws or speeds. Type B units are large capacity console designs capable of handling as many as 50 draws or speeds. **Louis Allis Co.**, Dept. P, 427 E. Stewart St., Milwaukee 1, Wis.

Circle 466 on Page 117

Level Transmitters

These level transmitting units are available in electric or pneumatic models that produce output signals suitable for use with most recording and/or control instruments or for long distance telemetering. They provide visual indication. Models are also available that provide alarm

and *On-Off* control. A magnetic position converter which is the basis of the MPT Series transmitters makes it possible to combine transmission, indication, alarm, and *On-Off* control in a single instrument. It can be used with a displacer or buoyant float and greatly increases the range of buoyant-float level instruments. The level transmitters can be supplied in special materials for toxic, corrosive, and high pressure (to 40,000 psi) services. Sensitivity is 0.25 per cent. **Brooks Instrument Co. Inc.**, Hatfield, Pa.

Circle 467 on Page 117

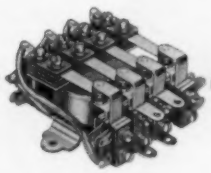
Commutating Switches

Series of mechanical commutating switches, designated Deltaswitch Model 210, are offered in one-pole and multi-pole configurations for commutation of 64 and 100 channels of information. Designed for 20 cycles per second operation, the switches are available with or without 1200-rpm, 115-v ac, 60-cycle synchronous hysteresis drive motors. A jet of mercury, replacing the conventional wiper arm for commutation, assures trouble-free life and low maintenance expense, thus making the switch suited to 24-hour per day operation. After commutating signals for over 1000 hours, the switch can be restored to like-new condition by cleaning the switch parts and replacing the mer-

4-POLE POWER CONTROL RELAYS FROM STOCK

Elgin Advance stocks the only 4-pole power control relay of this type on the market. Specify the PC Series when you require dependable current switching.

The PC Series features heavy load carrying capacity, combined with small size—a variety of contact arrangements—and a wide range of AC and DC coil voltages and resistances.

another example of  **reliable relayability**

SPECIFICATIONS

Contact arrangements—SPDT, DPDT, 3PDT, 4PDT
Contact rating—15 amps resistive, 5 amps inductive
Contact material—0.25″ dia fine silver
Coil voltages & resistances—wide range of AC and DC
AC power—10-12 VA, nominal
DC power—2-3 watts, nominal
Dimensions—1.906″ x 3.062″ x 2.593″, maximum
Weight—8 ounces, maximum

send for **latest data**

ELGIN advance RELAYS
THE ELECTRONICS DIVISION OF ELGIN NATIONAL WATCH COMPANY
2435 NORTH NAOMI STREET, BURBANK, CALIFORNIA

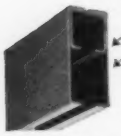
Circle 714 on Page 117

Power -Flex®

POWER AND FREE
OVERHEAD CONVEYOR SYSTEM*

WITH TELEMATIC
AUTOMATIC DISPATCH CONTROL

• *Simply set dials and Telematic guides carrier to any station in system*



Employs exclusive unitized "over and under" power and free rail which permits simple switching to right or left as desired.

Power-Flex is designed for automated materials forwarding applications in industrial plants, distribution centers, service buildings and department stores. The most economical system available for loads up to 600 lbs. per carrier. Savings in actual installations range from 25% to 60%.

*Systems in service for your inspection.

Engineered to your very specific requirements.

SEND FOR BROCHURE

Inquiries from your engineers or consultants welcomed.

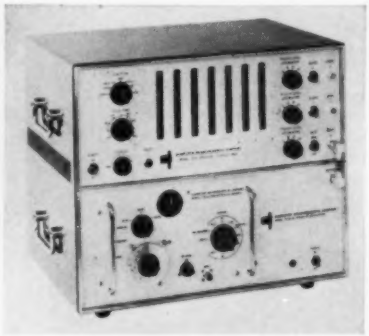
CM CONVEYORS

COLUMBUS McKINNON CORPORATION
Conveyor Division
TONAWANDA, N. Y.

Circle 715 on Page 117

cury. **Advanced Technology Laboratories Div., American-Standard Corp.**, Dept. AEI, 369 Whisman Rd., Mountain View, Calif.

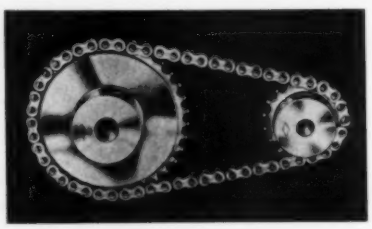
Circle 468 on Page 117



Counter-Timer

Unit consists of a solid state 10 mc Universal counter-timer and plug-in vacuum tube hetrodyne converter. Two converter plug-ins are available: Model 731A to cover the frequency range from 10 to 100 mc and Model 732A to cover the 100 to 220 mc range. The counter-timer performs seven basic functions selectable by a front panel switch. Output information from each DCU will operate digital printers, punches, inline readouts, and other data processing equipment. Measurement ranges are 0.1 microsec to 10^7 second for time interval and 0.1 microsec for period. Accuracy is ±1 count plus or minus the oscillator stability. Sensitivity is 0.25 v rms. **Computer Measurements Co.**, 12970 Bradley Ave., Sylmar, Calif.

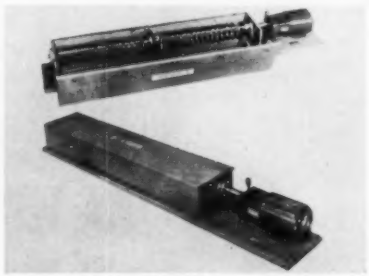
Circle 469 on Page 117



Package Drives

Complete package drives of Micropitch bushing-type chain and sprockets are available from stock for prototypes, pilot runs, and small production runs. Infinitely variable centers possible with Micropitch 0.1475-inch pitch, stainless steel chain permit wide freedom in the design of miniaturized power transmission, synchronizing, and conveying systems. A choice of 11 stainless steel sprockets with 8 to 48 teeth permits 121 different speed ratios. When used together, the chain and sprockets provide precise, nonmagnetic package drives suitable for small-space applications in cameras, computers, recorders, data processors, and other devices using miniature movements. **Diamond Chain Co.**, Dept. M, 402 Kentucky Ave., Indianapolis 7, Ind.

Circle 470 on Page 117



Sequencing Programmer

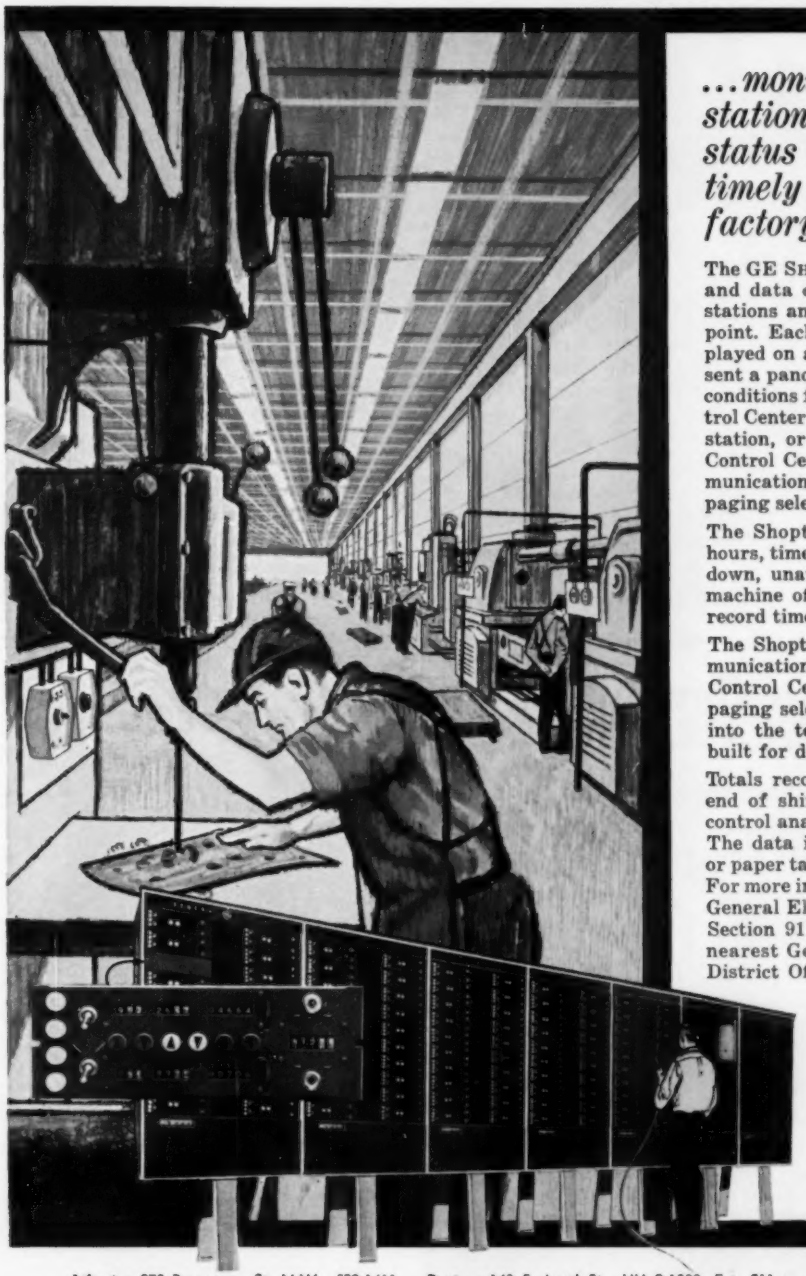
Employing a rotating cam limit switch with its own adjustable speed drive motor, this sequencing programmer is primarily used where sequencing of motions or functions is desired. Typical applications include sequencing of assembly machines, testing apparatus, and display lights. Unit allows individual adjustment of 30 circuits through the use of micro-adjust split lobe cams. By loosening a screw and rotating the cams relative to each other, a continuous range of an open and closed contact can be obtained from 352 degrees down to approximately 8 degrees of a revolution of the input shaft. **Gemco Electric Co.**, 25685 W. Eight Mile, Detroit 40, Mich.

Circle 471 on Page 117

Pressure Switches

System pressures or overpressures up to 250 psi produce no damage or leakage in this Deltadyne line of pressure and differential pressure switches. These switches cover the actuation range from 0.125 to 16

New GENERAL ELECTRIC SHOPTROL system



...monitors individual work stations...displays production status at a control center for timely reactions to factory conditions.

The GE SHOPTROL SYSTEM is a factory monitoring and data collection system that monitors work stations and records production data at a central point. Each work station's status is visually displayed on a Status Monitor. Status Monitors present a panoramic view of up-to-the-minute factory conditions for visual display at the Production Control Center. Work stations have an operator control station, or an alarm station terminating at the Control Center. Depending on complexity of communication needed and data to be transmitted, a paging selector may be added to each work station.

The Shoptrol System records, in hundredths of hours, time elapsed for operations, set-up and tear down, unavoidable delays, machine running, and machine off conditions. The Shoptrol System can record time elapsed, or count pieces or operations.

The Shoptrol System provides direct signal communications from work stations to the Production Control Center. The operator control station and paging selector have phone jacks to provide entry into the telephone intercom. Units are ruggedly built for dependable life in factory conditions.

Totals recorded from the Status Monitors at the end of shift produce information for production control analysis and management decision making. The data is readily convertible to punched cards or paper tape for input to a data processing system. For more information, write for brochure CPB-152, General Electric Company, Computer Department, Section 91M9, Phoenix, Arizona, or contact your nearest General Electric Computer Department District Office listed below.

THE GE SHOPTROL SYSTEM CONTRIBUTES TO GREATER PRODUCTION EFFICIENCY BY:

...providing constant communication between production control center, foreman, and work station operators.

...collecting and displaying current production data for each work station.

...increasing accuracy of production records.

...providing immediate production status for management at all times.

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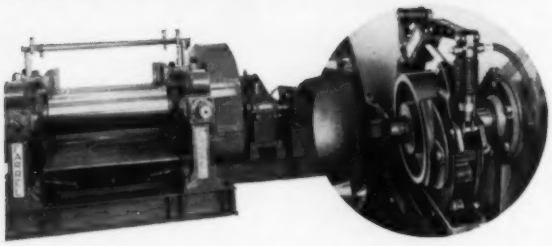
Progress Is Our Most Important Product

GENERAL ELECTRIC

CPA 91 (9-61)

WAGNER® EMERGENCY BRAKE SYSTEM



Stops "Inrunning rolls" within safety limit

A Wagner® A/H Emergency Brake System protects the operator of this Farrel-Birmingham rubber mill against the hazards involved in operating machinery with inrunning rolls. An industrial-type brake is applied by an air-operated hydraulic power cluster to smoothly stop rolls well within the limit set by safety codes. The Wagner system minimizes strain on the machine drive, and incorporates safety devices that provide protection in the event of power failure or loss of air pressure.

Wagner brake systems are easy to install . . . don't need special motor starters or controls, or direct current. Need little care, too . . . there is practically no lining wear; no heavy solenoid coils to burn out.

Apply these systems to your rubber or plastic mills, refiners, washers, crackers. Available with 6, 8, 10, 14, or 18 inch diameter brakes. Get full details from your Wagner Sales Engineer.

Wagner Electric Corporation

6430 PLYMOUTH AVENUE, ST. LOUIS 33, MO., U.S.A. W161-4

Circle 717 on Page 117

DIAMETER
15″

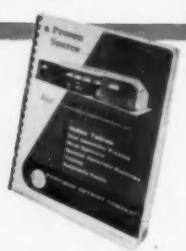
NUMBER OF STATIONS

Standards:
*3, *4, 6, 8, 12

Specials:
*5, 7, 9, 10, 11

*skip station units

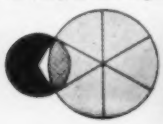
PDC-AM—15″ SERIES
"AUTOMATIC"
Geneva Motion Index Table



Write TODAY for new Catalog 60, for designers and engineers

COMPLETE with air motor, solenoid valve, limit switch, 3 relays and enclosure, airline oiler and airline filter . . . all that is necessary to interlock it with other automatic equipment.

MODIFICATIONS available with Electric Drive, Fluid Drive or vertical mounting.



PRECISION DETROIT COMPANY
20100 SHERWOOD • DETROIT 34, MICHIGAN

Circle 718 on Page 117

psi differential. Within the actuation range of a given switch, actuation pressure may be altered by turning a direct reading dial. These adjustable switches can be used in all types of fluid lines including pneumatic systems and compressed gas lines, hydraulic systems, process streams (chemical, petroleum, natural gas), and in other types of fluid systems where an alarm device is required. They feature the use of a magnetic detent so that a switch is either completely actuated or completely disconnected at all times. **Pall Corp.**, 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 472 on Page 117

Alarm Scanner

Device is capable of scanning up to 200 measured variables at the rate of one point per second. On discovery of any off-normal situation, it activates a recorder (which records the alarm condition measurement and reports its exact location), actuates a red alarm lamp, and energizes any desired external alarm system. Upon completion of these functions, the instrument returns to normal scanning—leaving the alarm lamp *On* until a reset button is depressed. The scanner features long life under continuous operation, quick alarm condition setting, and indicated scan cycle. It is now available to customer specifications in multiples of 20 to a maximum of 200 points. **Bristol Co.**, Waterbury 20, Conn.

Circle 473 on Page 117

here's a pilot you can trust!

In hundreds of thousands of heavy-duty industrial air valve applications, Valvair pilots have proved their ability to provide trouble-free performance and multi-million cycle dependability. They offer maximum simplicity, with but two moving parts . . . flow-through cooling, with air passing through the center of the pilot for heat dissipation during rapid cycling . . . low current draw to prevent overheating, even when continuously energized for hours, days or weeks! And, Valvair pilot coils are potted in resin for moisture-resistance . . . are guaranteed against burn-out for the life of the valve.

What's more, Valvair's pilot is truly universal . . . interchangeable for use on any Speed King® valve. There's no need to stock a confusing quantity of different pilot assemblies or a myriad of parts. So, stockroom and in-service maintenance problems are minimized.

Pilot performance is vital to the dependable operation of the machinery you design, build or use. Your nearby Bellows-Valvair Field Engineer can show you why Valvair's pilot is the one you can trust.

For more information, write for Bulletin FL-61. Address Bellows-Valvair, Akron 9, Ohio, Dept. AU-961.

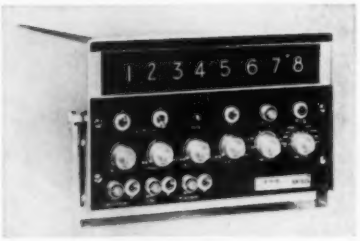
Bellows-Valvair

AKRON 9, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

8192

Circle 719 on Page 117



Counter-Timer

Model 925 solid state 20 MC Universal counter-timer is designed to offer reliable counting of periodic or random electrical events and precise measurement of frequency, period, and time intervals. A built-in memory provides readout storage, continuous display while counting, and frequent sampling. It operates for all eight digits. The counter-timer can be used in laboratory flow calibration systems, velocity computations, low frequency period measurement, frequency monitoring, engine or electric motor rpm measurement, oscillator calibration, timing relays, and intervalometer calibration. **Erie-Pacific, Div., Erie Resistor Corp.,** 12932 South Weber Way, Hawthorne, Calif.

Circle 474 on Page 117

Electromagnetic Pickup

Magnetic pickup experimental assortment is complete with subminiature, miniature, standard output, and high output pickups; AN connector; plastic box; and detailed operating and application data. The pickup is a self-generating input transducer providing the connecting link between mechanical motion and instrumentation. It generates voltage and power without the aid of power supplies and seldom needs additional amplification to actuate electrical or electronic circuits. The pickup generates voltage/frequency from mechanical motion (without contact) in proportion to the speed of metal objects interrupting its magnetic field. **Electro Products Laboratories Inc.,** 4500 N. Ravenswood Ave., Chicago 40, Ill.

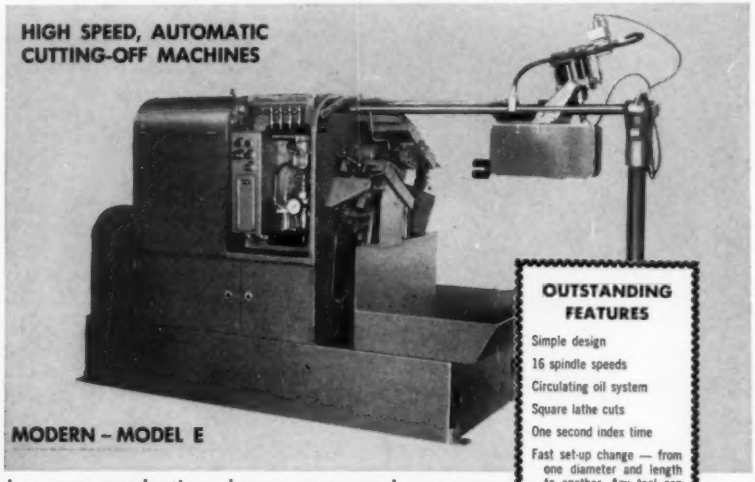
Circle 475 on Page 117

Motion Transmitter

Pneumatic motion transmitter has been designed to transmit linear motion as a pneumatic signal for indication on a remote receiver gage. Motion is sensed by the valve actuating rod and causes a change in output air pressure. This signal is directly proportional to the motion and is available for control. The actuating rod tip can be modified to suit potential applications throughout industry. This instrument has either a 3-15 or 3-27 psi output signal, with supply air requirements of 18-20 and 30-35 psi, respectively. **Gauge & Instrument Div., Manning, Maxwell & Moore Inc.,** Stratford, Conn.

Circle 476 on Page 117

HIGH SPEED, AUTOMATIC CUTTING-OFF MACHINES



MODERN – MODEL E

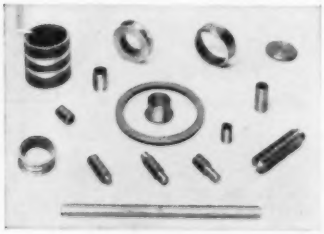
OUTSTANDING FEATURES

- Simple design
- 16 spindle speeds
- Circulating oil system
- Square lathe cuts
- One second index time
- Fast set-up change — from one diameter and length to another. Any tool can be changed without disturbing others.
- All cams, adjustments and working parts for cross slide are outside for quick, easy adjustment.
- Chip pan slides out, for easy dumping.
- Power, speed and rigidity for cast alloy and carbide blades.
- Special spindle bearing takes all collet thrust. No thrust on main taper roller spindle bearings.

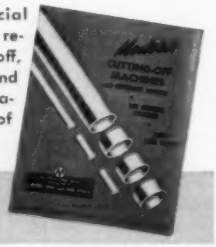
Increase production, lower costs and cut any material that can be turned — bar stock up to 3" O. D. — tubing up to 8" O. D., to lengths from a fraction of an inch to several feet, with micrometer accuracy. Ideal for use with carbide tools.

We also engineer and build machines — using the same bodies and spindles — for such operations as trimming ends of drawn shells and filler caps. Send prints for quotes.

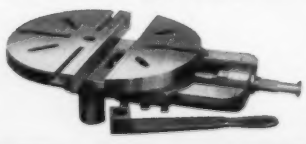
Catalog and production figures mailed on request.



We can furnish special tooling to meet your requirements — to cut-off, form, groove, flange and chamfer in a single operation, at a high rate of speed. Send prints.



MODERN MACHINE TOOL COMPANY
2005 Losey Street • Jackson, Michigan



FREE TRIAL OFFER. Safe, positive, fast set-ups. The Modern Safety Drill Table handles odd, irregular shapes without V-blocks, clamps or parallels. Ideal for maintenance work. Guaranteed to save its cost in labor alone every 6 months. Sizes from 8" to 27½" dia. Try it at our expense. No obligation.

Circle 720 on Page 117

AUTOMATIC, PRECISION DRILLING

EVERY TIME

. . . new Gardner-Denver "Tru-Feed"® drills

Rugged, air-powered Gardner-Denver "Tru-Feed" drilling units drill holes up to 1½" in diameter even in hardest metals. Positive mechanical feed assures clean, accurate holes. Precise control of entire operating cycle, and full-power operation at any speed, give smooth, fast performance. Drill's adjustable, rapid advance and sensitive thrust-control features are big cost-savers in production drilling. Available in either portable or stationary models.

Automatic operation—Just push a button to start cycle. When hole is drilled, tool retracts and automatically shuts off.

Adjustable stroke—Set two stops to utilize any portion of stroke. Front stop controls hole depth to within .005".

Portable or stationary—For stationary applications, use mounting brackets or drill bushing tips. In portable use, a simple drill bushing fixture lets you move drill from hole to hole. "Tru-Thread"® tapper used in same tooling maintains concentricity between drilled hole and tap.

Adaptable to Automation—Start and stop poppets may be replaced with adapters for remote operation. Pressure-type poppets may be used. A pressure signal is built-in to control sequence of indexing and clamping fixtures.

Powerful and versatile—Compact, heavy-duty air motors develop up to 1½ hp.—provide dependable power for hard-metal drilling, gun-drilling, reaming, boring, counterboring, countersinking and other production operations at speeds from 75 to 4400 rpm, and feeds from .0005" to .0145" per revolution.

For details, request bulletins 93 and 96 on Gardner-Denver automatic drilling and tapping equipment.

Companion Tools for Precision Tapping. "Tru-Thread" tappers, incorporating a lead screw, assure precision-tapped holes of the highest quality in hard or soft metals. Portability provides accurate, economical tapping of holes in any workpiece—eliminating the need to move it to a machine tool.

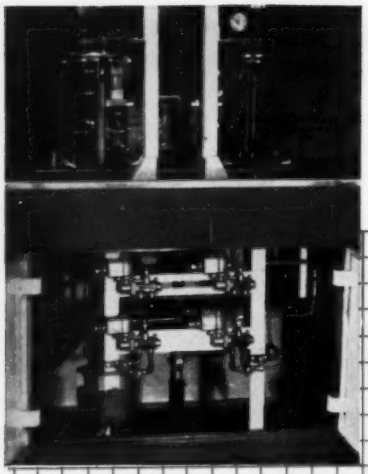
EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

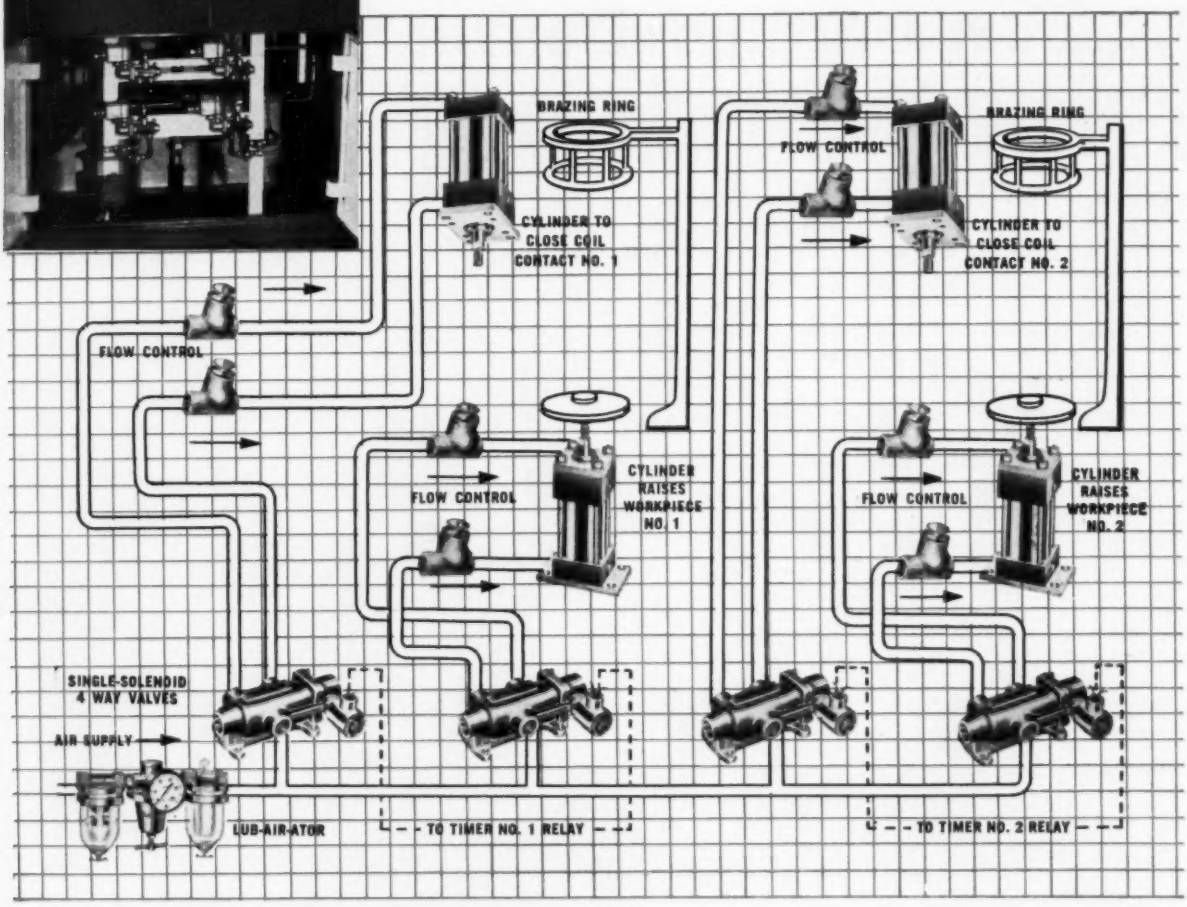
Gardner-Denver Company, Quincy, Illinois—Offices in principal U.S., Canadian and Mexican cities
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario

International: Gardner-Denver International Division, 233 Broadway, New York 7, N.Y.
International Offices: Buenos Aires, Argentina; Artarmon, N.S.W. Australia; Brussels, Belgium; Rio de Janeiro, Brazil; Santiago, Chile; Barranquilla, Colombia; Lima, Peru; Ndola, N. Rhodesia; Salisbury, S. Rhodesia; Johannesburg, Transvaal

Circle 721 on Page 117



General Electric Company's Apparatus Service Shop in Detroit, Mich., uses Schrader air circuits to actuate and control this brazing machine. It enables one man to braze 120 planet carrier gear assemblies for automotive transmissions in one hour. Double-acting cylinders, actuated by solenoid valves, lift the assembly into position within the coil for brazing the shaft to the gear, and lower it for water quench. JIC cylinders control the induction heating coil contacts. According to Frank A. Ross, the designer, Schrader's Flow Control Valves close contacts so gently that they perform 750,000 cycles before needing replacement. In addition, air works successfully in a strong magnetic field, and the circuits can be simple.



TOUGH BRAZING JOB BECOMES A BREEZE... WITH SCHRADER AIR CIRCUITRY

PROBLEM: Strong magnetic field . . . complex movement of parts . . . speed requirements . . . precise actuation of coil contacts.

SOLUTION: Simple Schrader air control of mass production operations.

Schrader Air Products are designed to operate together in varied combinations to produce practically unlimited results. Their quality and versatility make them capable of *simplifying* production . . . while speeding it up . . . at unmatched low cost. Are you failing to ultilize fully the air you already have? Follow this Detroit plant's example. Examine your production facilities with air in mind. Make many operations simpler and more efficient by applying any or all of the complete line of Schrader Air Control Products.

This new Schrader catalog is available at your Schrader distributor, who is stocked with the complete range of sizes and types of Schrader air circuitry products. Consult the Yellow Pages or write Schrader.

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472 Vanderbilt Ave., Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

Circle 722 on Page 117

AUTOMATION

catalogs and literature

Latest automation information. For copies use card on page 117

Switch Tube Manual

Electronic Components Div., Burroughs Corp., P. O. Box 1226, Plainfield, N. J. —24 page handbook—Data are contained in this brochure on a Beam-X switch. Applications for the switch include counting, coding, distributing, converting, multiplexing, switching, and sampling. The brochure covers theory of operation, circuit design, and characteristic curves. Included are a detailed glossary and a maintenance and troubleshooting section.

Circle 477 on Page 117

Digital Logging Technique

Bristol Co., Waterbury 20, Conn.—4 page pamphlet—The method employed by a Data-Master digital logger to present, in digital form, the measurement of a physical variable is discussed in Product Data D400-2. Block diagrams are used to demonstrate how a physical property (such as flow or pressure) is measured, converted to an electrical input, and then delivered in printed digital form. Four digital loggers are illustrated and discussed.

Circle 478 on Page 117

Linear Metering Pumps

Airmatic Valve Inc., 7313 Associate Ave., Cleveland 9, Ohio—6 page pamphlet—Data are contained in Bulletin 91048 on a line of Measure-Matic pumps for metering, injecting, sampling, feeding, mixing, and lubricating. Units are solenoid operated and air powered. Adjustable stroke models can be preset to feed from 0 to 25 cc per stroke. In addition to ordinary liquids, difficult materials such as viscous plastic resins, glues, and metal bonding mastics can be pumped. Cutaway diagrams illustrate internal features of the devices.

Circle 479 on Page 117

Radiation Surface Pyrometers

Atlantic Pyrometers Inc., 190 Warburton Ave., Hawthorne, N. J. 1 page pamphlet—Bulletin 0057 describes the performance features of a line of Type SP portable surface pyrometers, including noncontacting measurement, automatic compensation for errors from emissivity variations, and standardized temperature calibration without field sample test runs. These features are now available in models designed for continuous recording and control of sheet, web, and film temperatures. The pyrometers find application in the rubber, plastic, leather, and paper industries. They are also used in equipment for applying special coatings on metal strip.

Circle 480 on Page 117

Handling Conveyors

Conveyor Systems Inc., 6451 Main St., Morton Grove, Ill.—56 page handbook—Data are contained in Catalog 70 on a line of bulk and package handling conveyors that includes both portable and pre-engineered units. Brochure incorporates many illustrations of engineered systems, special applications, and package and bulk handling equipment being applied in a variety of industries. Details are also provided on the engineering services offered by this company and the parts and repair facilities maintained for servicing customer installations.

Circle 481 on Page 117

Electric Clutch/Brakes

Dial Products Co., 19 Cottage St., Bayonne, N. J.—17 page booklet—Catalog 963 describes a line of clutch and brake combinations that employ standard stock components and that can provide a large variety of operating characteristics. Feature of these units is that each half of the set may be selected to conform to the driving or braking needs of the equipment, without compromising the specifications for the other half. Minimum static torque output is 30 oz-in. at 2 watt power input for size 100 and 110 oz-in. at 3½ watts for size 130.

Circle 482 on Page 117

Nuclear Level Gages

Ohmart Corp., 2236 Bogen St., Cincinnati 22, Ohio—4 page pamphlet—Bulletin 106 covers a line of nuclear gages available to industry for measuring and controlling the level or interface position of liquids, solids, and slurries in silos, bins, process vessels, and pipes. The gages can provide recording only, recording and simple alarm, high and low level alarm, or full proportional control. Line diagrams illustrate typical applications of the gamma ray devices.

Circle 483 on Page 117

Plastic Weighing Equipment

Exact Weight Scale Co., 541 E. Town St., Columbus 15, Ohio—32 page catalog —Covered in this catalog is a line of precision scales and weighing equipment specifically designed for the plastics industry. The scales are available with various capacities in manual, semiautomatic, and fully automatic models. Several models can be integrated in production lines.

Circle 484 on Page 117

Closed Circuit Television

Electronics Div., Fairbanks, Morse & Co., 505 Oakwood Ave., West Hartford 1, Conn.—36 page handbook—Described in this booklet is an E.M.I. closed circuit television system of providing visual intercommunication for office, factory, and commercial use. It has been manufactured in a series of units so that a simple system consisting of a manually-controlled camera, control unit, and monitor, may be extended at any time by the addition of remote control units. Specifications, operating characteristics, and various unit illustrations are included. Details are provided regarding optional accessories to basic equipment.

Circle 485 on Page 117

Processing Machinery

Traylor Engineering & Manufacturing Co., Div., Fuller Co., 1559 Mill St., Allentown, Pa.—4 page pamphlet—Rotary kilns, mills, crushers, feeders, and other equipment for the mining and processing industries are described and illustrated in Bulletin TGB-2A. Photographs of the machines are included, as well as an installation picture of a rotary lime sludge kiln.

Circle 486 on Page 117

Time Control Handbook

Haydon Div., General Time Corp., Torrington, Conn.—74 page handbook—Booklet entitled "Basic Timing Instruction Manual" starts with an elementary explanation of time controls and circuits and progresses to complex application diagrams. It is intended as a beginning text for rapid understanding of basic time control principles and applications. Specific subjects covered in the manual include: Basic construction of time controls,

switches and circuits, elapsed time indicators, cycle timers, interval timers, time delay timers, and reset timers.

Circle 487 on Page 117

Control Switches

Sirco Products Inc., 2706 3rd Ave., Seattle 1, Wash.—24 *page catalog*—Catalog 61 covers a line of switches for controlling pressure, vacuum, liquid level, bin level, temperature, and many other variables. These switches feature positive on-off switch action in differential applications. They are protected against overpressure and surges. Photographs of various models are provided.

Circle 488 on Page 117

Pneumatic Cylinders

Sheffer Corp., 326 W. Wyoming Ave., Cincinnati 15, Ohio—20 *page booklet*—Data are contained in Bulletin 161 on a series of dimensionally interchangeable 250 psi cushion type pneumatic cylinders, in bore sizes of 1⅛ through 14 inches, with 20 standard mountings. Designated A Series, these cylinders meet all J.I.C. standards and feature easily serviced rod cartridges removable with only a wrench. Booklet provides dimensional drawings of the various available models.

Circle 489 on Page 117

Impulse Counter

Automatic Timing & Controls Inc., King of Prussia, Pa.—4 *page pamphlet*—Series 310 automatic reset impulse counter is subject of Bulletin N-310. Counter features new clock escapement mechanism and impulse motor. Data on construction, application, installation, specialized functions, electrical data, and basic circuit arrangements are included. Counter is used for industrial processes, laboratory work, and machine automation.

Circle 490 on Page 117

Differentials and End Gears

Instru-Lec Corp., 520 Homestead Ave., Mount Vernon, N. Y.—4 *page pamphlet*—Folder contains data on a line of precision differentials for instruments, computers, servomechanisms, and other electromechanical devices. Keyed drawings and tables are included for solid and hollow shaft differentials. Precision end gears with various diametral pitches and numbers of teeth are also described.

Circle 491 on Page 117

Panel Instruments

Weston Instruments Div., Daystrom Inc., 614 Frelinghuysen Ave., Newark 12, N. J.—6 *page pamphlet*—Bulletin 01-113 describes a line of standardized panel instruments available in 4½, 5½, and 7½-inch sizes. This line is composed of ac and dc ammeters, milliammeters, microammeters, and voltmeters. Instruments of 1 per cent accuracy feature a knife-edge pointer and mirror scale; models of 2 per cent accuracy are equipped with a lance type pointer and plain scale. Meter movements are available in both shielded or unshielded types with a wide choice of instrument ranges.

Circle 492 on Page 117

Electron Beam Welding

Sciaky Bros. Inc., 4915 W. 67th St., Chicago 38, Ill.—8 *page bulletin*—Bulletin 344 contains data on a line of electron beam welding equipment capable of both basic research and practical production applications. Materials ranging from 0.005-inch thick tantalum to ¾-inch plates of stainless and 4340 steel can be welded. Electron gun will weld at any angle, and both gun and fixture can be moved within the chamber while welding. Diagrams illustrate constructional features as well as typical welds produced by this equipment.

Circle 493 on Page 117

Electronic Instruments

Erie-Pacific, Div., Erie Resistor Corp., Hawthorne, Calif.—6 *page pamphlet*—Short Form Catalog covers a line of electronic counters, digital instruments, interval timers, and digital control systems. Each instrument is shown separately with suggested uses and major specifications.

Circle 494 on Page 117

Parts Feeder

Count-O-Matic Inc. Div., U. S. Engineering Co., 40-24 22nd St., Long Island City 1, N. Y.—4 *page pamphlet*—Bulletin B-31 provides data on a high-speed hopper, adjustable for part size, shape, and count. Designated as Hoppermatic, this unit is capable of handling up to 200,000 items per hour. It performs parts feeding, orienting, and counting operations. Applications include use with assembly machines, processing machines, and packaging machines.

Circle 495 on Page 117

Magnetic Tape Tester

General Kinetics Inc., 2611 Shirlington Rd., Arlington 6, Va.—2 *page pamphlet*—Brochure describes a Model 7 magnetic tape tester designed specifically for preventive maintenance of magnetic tapes in computer installations and for production testing of new tapes. Features include a provision to stop a tape so that its error regions come to rest automatically at a repair workstation. A circular graph recorder gives an accurate, permanent record of the locations of all error regions on a tape.

Circle 496 on Page 117

Second Operation Machine

Standard Tool & Mfg. Co., 738 Schuyler Ave., Lyndhurst, N. J.—10 *page bulletin*—Bulletin 61 outlines the features of a multiple second operation machine, designated MSO. It provides case history examples of second operation applications of the machine, with illustrations and mechanical drawings of typical parts produced with time cycles.

Circle 497 on Page 117

Infrared Heating Equipment

Fostoria Corp., Dept. 102, 1200 N. Main St., Fostoria, Ohio—4 *page pamphlet*—Form 61-124 covers a line of high intensity infrared equipment that utilizes fluid cooling to obtain the maximum capabilities of quartz lamp sources. The equipment offers precision control of temperatures up to 3000 F with no contamination during processing. Other advantages include instant heating, immediate shutoff, compact design, long life, and low maintenance.

Circle 498 on Page 117

Chemical Processing Equipment

Fuller Co., Catasauqua, Pa.—12 *page booklet*—Bulletin G-3E covers major product lines for the chemical processing industries. Discussed are design and performance characteristics of Fuller-Kinyon pumps, Airveyor pneumatic conveyors, Airslide fluidizing conveyors, rotary compressors and vacuum pumps, horizontal grate coolers, suspension-type preheaters, positive displacement blowers and gas pumps, induced-draft fans, and industrial exhausters. A separate section describes accessory equipment.

Circle 499 on Page 117

Punched Card Reader

Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.—2 *page pamphlet*—Data are given in Bulletin DPS-A43 on a CR-201 card reader designed to transport IBM cards from a card hopper, past two read stations, and into a card stacker at a speed of 30 cards per minute. The reader may be operated either from an integral control panel or by a remote system. It will accept cards perforated in any binary or alphanumeric code.

Circle 500 on Page 117

Power Transmission Equipment

Browning Manufacturing Co., Maysville, Ky.—24 *page catalog*—Catalog GC-101-F illustrates and describes a line of power transmission equipment. It includes a line of V-belts and such associated items as wide range variable speed belts, Poly-V belts and gearbelts. Feature of this line is a malleable iron bushing system which is interchangeable throughout the entire product line. Also covered is a comprehensive line of roller chain and sprockets.

Circle 501 on Page 117

Metal Detectors

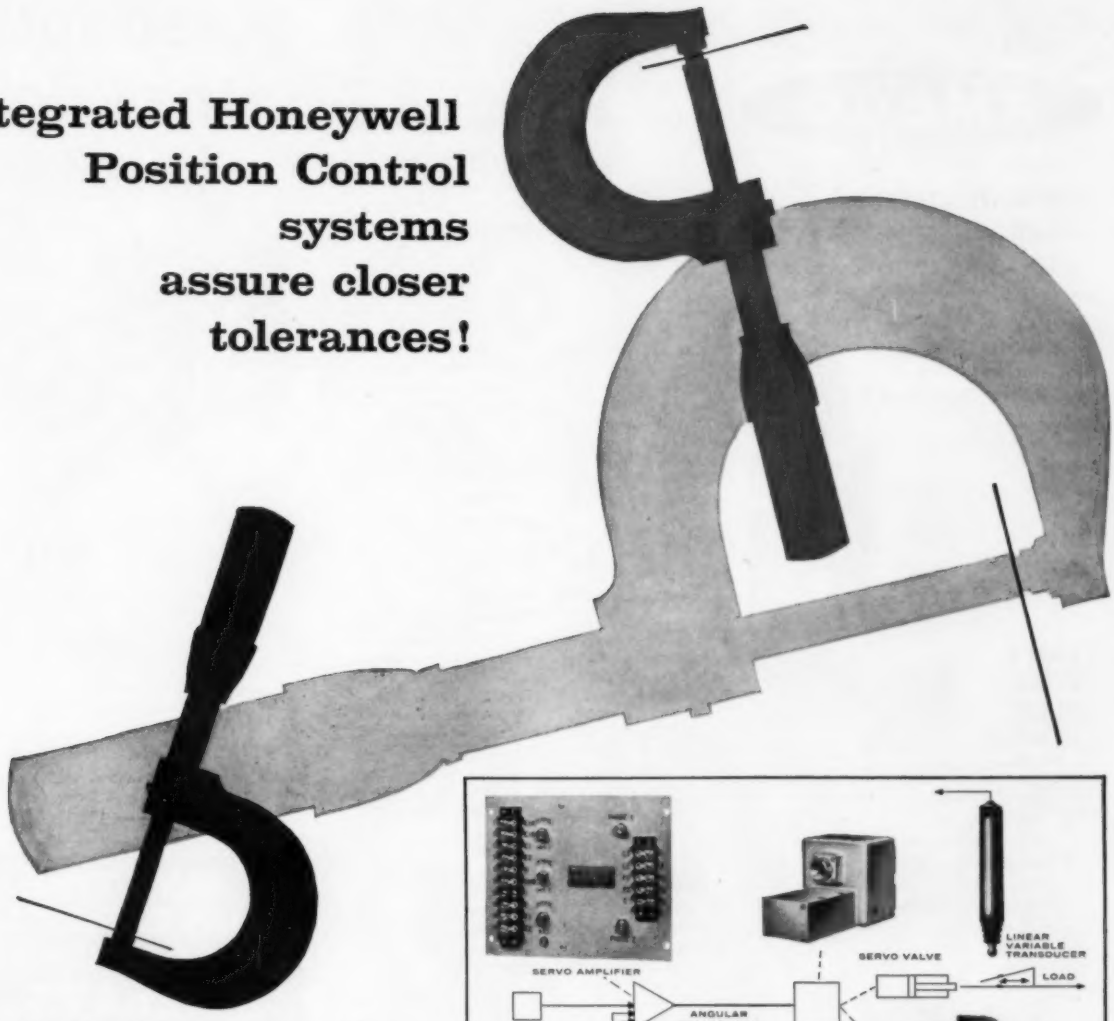
Morehouse Machine Co., 1742 Sixth Ave., York, Pa.—8 *page bulletin*—Bulletin 203 explains the environmental and operational factors which affect the sensitivity of radio frequency metal detectors. The function and proper application of such devices are illustrated through reference to a Metabloc metal detecting system. Several types of search coils and control units are shown, and application data given.

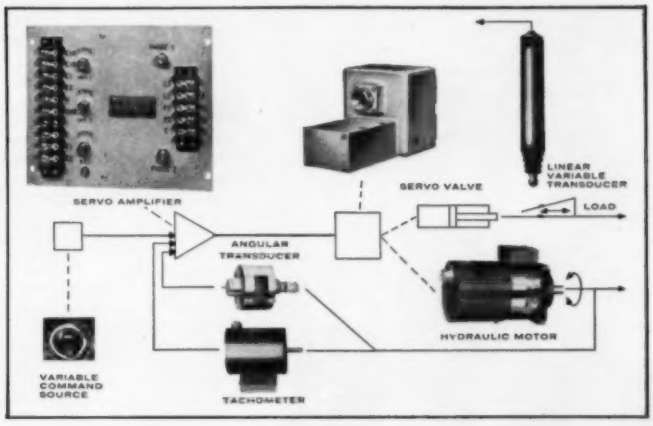
Circle 502 on Page 117

Production Colorimetry

Colorimetry Div., Allied Research Associates Inc., 43 Leon St., Boston 15, Mass.—2 *four-page pamphlets*—Data are contained in these booklets on a Green-Bartlett technique of high-speed, fully automatic color measurement. Designed to provide precise color identifications at rates as high as 30 pieces per second, this equipment is well suited to feedback

Integrated Honeywell Position Control systems assure closer tolerances!





Honeywell "building-block" servo components can be field adjusted to assure close repeatable tolerances for industrial process control.

Now you can achieve and maintain closer tolerances for your industrial mechanisms. Even under conditions of high force and fast-stroking rates, Honeywell components assure positive, accurate servo positioning, uninterrupted processing and improved handling of materials.

System performance is the result of: (1) combining the sensitivity and high resolution of electronics with the fast response, tight actuation and variable power of hydraulics; (2) integrating components, controls and servo accessories in "building block" sequence for versatility and repeatable accuracy; and (3) designing fully transistorized components which incorporate built-in electrical feedbacks and the same high resolution and versatility of Honeywell Servo valves.

For details on any or all of Honeywell's Position Control systems, call your nearest Honeywell office; or write Honeywell, Dept. AO-9-135, Minneapolis 8, Minnesota.

Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL
Sales and service offices in all principal cities of the world. Manufacturing in the United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Circle 723 on Page 117

another triumph in automation

AMECO

AUTOMATIC STACK HEIGHT SELECTOR

Accurate to within one lamination

AMECO's new selector speeds the laminate stacking operation by 2½ times. Turns out over 500 per hour with constant accuracy.

AMECO STACK HEIGHT SELECTOR

- Measures pre-set stack height within plus or minus one lamination.
- Handles up to 4" dia. lamination and up to 2" max. height of stack.
- Accepts lamination even with excessive burrs.
- Changes over easily for different sizes.

STATOR PACK WELDER

Designed to weld sub-fractional stator cores from 2" to 4" dia. and from ½" to 2" in height. Four welds are made simultaneously. Complete operation can be made fully automatic with some modifications to both welder and measurer.

AUTOMATION MACHINES & EQUIPMENT CO., INC.
3130 W. Mill Rd. Milwaukee 9, Wisconsin
FLagstone 2-7250

Circle 724 on Page 117

process control, continuous color inspection, and high-speed color sorting and grading. One booklet covers general product sorting capabilities of the color measurement equipment. The second booklet, covers technical details and applications of a colorimeter that combines an electronic-optical head with a small-scale digital computer.

Circle 503 on Page 117

Malfunction Detectors

Aeronautical & Instrument Div., Robertshaw-Fulton Controls Co., Santa Ana Freeway at Euclid Ave., Anaheim, Calif.—2 pamphlets—Data are provided in these two bulletins on a line of Vibraswitch malfunction detectors. Application Report V-101 outlines how the detectors, mounted on turbines, fans, pumps, blowers, and motors, provide automatic alarm or shutdown whenever they sense impending mechanical failure. Report V-107 describes the use of four malfunction detectors on a 2000 hp electric motor-driven multistage oxygen compressor.

Circle 504 on Page 117

Fine Powder Feeder

Sylvester & Co., 17706 Miles Ave., Cleveland 28, Ohio—6 page pamphlet—Bulletin introduces a Sylco CCC fine powder feeder, Model Mark VII, designed for metering uniform quantities of dry powders. This feeder is employed to feed refractory, metal, oxide, and abrasive powders for flame coating, plasma-jet coating, abrasive-powder cutting, and a variety of other powder-feed applications.

Circle 505 on Page 117

Pressure Transducer

Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass.—2 page pamphlet—Differential pressure cell described in Data Sheet 4381 is a bellows type unit designed to accurately measure static and low frequency differential, absolute, or gage pressures. Output is an electrical signal that can be indicated, recorded, or converted to magnetic tape for use as a computer input. Type MM SR-4 pressure cell is available in capacities of 15, 30, and 60 psi. Performance specifications are listed.

Circle 506 on Page 117

Markers and Decorators

Apex Machine Co., 14-13 118th St., College Point 56, N. Y.—4 page pamphlet—Bulletin provides data on a line of marking and decorating equipment that employs offset printing, flexographic printing, hot stamping, coating, and dipping methods of operation. Various machines and typical products handled are illustrated.

Circle 507 on Page 117

Back-Up Rings

Parker Seal Co., 10567 Jefferson Blvd., Culver City, Calif.—8 page bulletin—Data are contained in Catalog 5482 on a line of contoured and continuous back-up rings, designated Parbaks. These rings increase O-ring sealing effectiveness. They increase lubrication and prevent O-ring ex-

Readouts that do more...

Series 80000

DISPLAY NUMBERS, WORDS, COLOR, and SYMBOLS

Features the largest readout area (7⅞ sq. in.) employing these applications. Price complete from $33.00. Your inquiry regarding readouts that do more, for you, is invited.

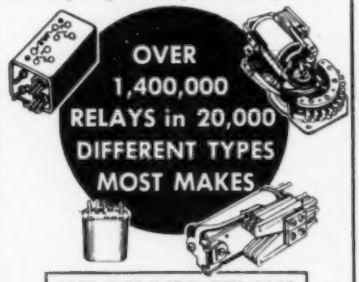
INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
5528 Vineland Ave., North Hollywood, Calif.

Circle 725 on Page 117

SAVE TIME and EXPENSE on PURCHASING RELAYS

IMMEDIATE DELIVERY
Off Shelf Items

DELIVERY WITHIN 1 WEEK
Items requiring assembly and/or adjustment



WE DELIVER RELAYS NOT PROMISES

PRODUCTION QUANTITIES IN STOCK
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Circle 726 on Page 117

trusion. Units are continuous, one piece rings without cuts or spirals, so they cannot cut or pinch. The rings can be stretched into place and installed with concave side facing toward or away from O-ring.

Circle 508 on Page 117

Machine Stop

Rands Products Inc., 131 Ash St., Willimantic, Conn.—2 page pamphlet—Data are contained in this bulletin regarding an instant action machine stop for coil stock. This Feed-Off unit stops a machine when length of stock per stroke drops below a preset minimum, when stock is oversize in thickness, when stock is undersize in thickness, when defects such as burrs and tears occur in stock, and when stock coil end approaches. It functions as a guide for stock entering a machine and can be easily adapted to suit individual requirements.

Circle 509 on Page 117

Hydraulic Equipment

Century Hydraulics, Div., Century-Detroit, 6101 Concord Ave., Detroit 11, Mich. —19 page booklet—Catalog illustrates and describes a line of hydraulic equipment including J.I.C. approved reservoirs, oil level sight gages, and accessories. Design and build services for hydraulic power units, special machines, test stands, and presses are announced Photographs of the various products are included.

Circle 510 on Page 117

Strip Gage Control

General Electric Co., Schenectady 5, N. Y.—2 page pamphlet—Bulletin GEA-7224 describes an equipment system for cold-strip steel rolling mills utilizing x-ray sensing gages and a static, Directo-Matic control to keep strip on gage automatically. It shows how the equipment is used to reduce downtime and achieve greater yield of usable strip per ton of metal rolled. The arrangement and operation of the system is diagramed. Included are descriptions of optional functions such as speed programming, reel forcing, and tension limiting.

Circle 511 on Page 117

Rotary Air Devices

Gast Manufacturing Corp., 23015 Highway M-139, Benton Harbor, Mich.—12 *page booklet*—Catalog 660 describes a line of rotary air motors, air compressors, and vacuum pumps. Six sizes of air motors, 1/20 to 7 hp, are explosion-proof and variable-speed. Some are reversible. Compressor sizes are from 0.6 to 45 cfm and supply air at up to 30 psig. Vacuum pumps range from 0.6 to 50 cfm with ratings up to 28 inches Hg. Both oil-less and lubricated models are offered.

Circle 512 on Page 117

Power Transmission Units

Hub City Iron Co., Aberdeen, S. Dak.—36 page catalog—Catalog AG61 covers the following components: Shaft mounted bevel gear units, work gear speed reducers, spur gear drives, and right angle bevel gear speed changers. Schematic diagrams indicate dimensions of the various items. Charts provide data on recommended horsepower-torque ratings. Specifications are given and construction features are listed and explained.

Circle 513 on Page 117

Materials Handling Concept

Rapids-Standard Co. Inc., 342 Rapistan Bldg., Grand Rapids 2, Mich.—16 page booklet—A warehousing approach to management of materials flow is explained in detail in Bulletin 2800. Illustrating equipment and techniques for live storage and transportation of raw materials and finished products, this brochure offers ideas based on successful solutions to problems of materials management.

Circle 514 on Page 117

Data Processing Units

Friden Inc., Promotion Planning Dept., 1 Leighton Ave., Rochester 2, N. Y.—28 page catalog—Catalog SP-8604-R5-ROCH covers over a dozen major data processing systems which are controlled automatically by the firm's business machines. Step-by-step illustrations and concise explanations of such diversified applications as letter writing, purchasing, manufacturing control, and bank check coding illustrate the over-all flexibility and versatility of this equipment. The tape-operated machines described include: Flexowriter for document writing, Computyper for invoicing, Teledata for code transmission, Collectadata for collecting work data, and Selectadata for data selection-readout.

Circle 515 on Page 117

Ruggedly Built

— AND THOROUGHLY PROVED BY YEARS OF HARD EVERYDAY USE IN THOUSANDS OF PLANTS

HANSEN

ONE-WAY SHUT-OFF

QUICK-CONNECTIVE

PUSH-TITE COUPLING

Here's the fluid line coupling that can really take it. The ability of Hansen Push-Tite Couplings to withstand severe service—with practically no maintenance—has been thoroughly proved by years of hard, everyday use in thousands of plants.

To connect a Hansen Push-Tite Coupling, you merely push the Plug into the Socket—as easily as plugging in your electric shaver. Flow is automatic—instantaneous. Plug swivels freely—no kinking of hose. To disconnect, pull back sleeve on Socket. Instantly and automatically, Socket shuts off flow of air or liquid.

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INSTANT
AUTOMATIC FLOW OR SHUT-OFF

Leak-Proof, Minimum Wear Locking Device

Locking pins in Socket afford uniform large area contact with Plug—thereby preventing wear and subsequent leakage. The socket head, containing locking device, is factory assembled into a rugged integral unit which cannot be readily injured or have component parts lost by casual tampering.

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Here is an always ready reference when you want information on fluid line couplings in a hurry. Lists complete range of sizes and types of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight Through Couplings.

Representatives in Principal Cities ...See Yellow Pages

SINCE 1915 — QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

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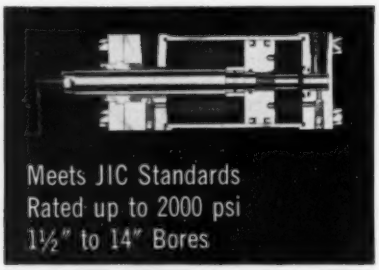
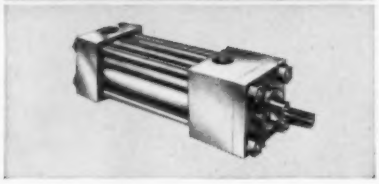
Circle 727 on Page 117

NEW O-M SQUARE HEAD HYDRAULIC CYLINDER

now available

SERIES "L"





For years, you have looked to Ortman-Miller for the original space-saving, tie-rodless air and hydraulic cylinders. Now, with the introduction of the new Series "K" air cylinder, recently announced, and the new Series "L", hydraulic cylinder, featured above, you can look to O-M for all of your cylinder requirements.

A product of the teamwork of O-M specialists, this new Series "L" hydraulic unit reflects the research, design, engineering and production capabilities and experience that are an integral part of every O-M cylinder. The result, a quality, hydraulic cylinder designed for long service, high operational efficiency and quick, easy maintenance, dimensionally interchangeable with most cylinders of a like type.

For complete details mail coupon today for Bulletin No. 116 in which all cylinders have been dimensioned in accordance with NFPA recommendations for your convenience.

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Circle 728 on Page 117

Photoelectric Counter

Electronic Controls Div., Veeder-Root Inc., Danvers, Mass.—2 *page pamphlet*—General purpose photoelectric counter (Series 1810) is described and illustrated in this bulletin. Details are provided on how a photohead exciter (Model PL) directly actuates a relay in the counter without the need for an amplifier. Also described is a photoelectric control unit (Series 1811) that can actuate auxiliary equipment through an integral power relay. Adjustable time delay increases flexibility of the unit.

Circle 516 on Page 117

Pneumatic Assembly Tool

Cramer Div., Giannini Controls Corp., Machine Tool Dept., Centerbrook, Conn.—6 *page pamphlet*—Data and illustrations are contained in Bulletin CAS-2 on an air operated assembly tool that combines pressing and staking operations. Automatic and manual models provide independent adjustment of pressing and staking forces up to 1 ton. Production of up to 1400 assemblies per hour is possible on one model equipped with an automatic parts ejector.

Circle 517 on Page 117

Flat Top Conveyor Chain

Acme Chain Corp., 821 Main St., Holyoke, Mass.—4 *page pamphlet*—Bulletin No. 9 describes a flat top conveyor roller chain that will operate continuously with minimum wear. Top plates of the chain are made of Delrin, a thermoplastic material that combines low distortion, low moisture absorption, and low coefficient of friction. Plates have inherent resistance to attack by food substances, industrial oils, greases, and a variety of other materials.

Circle 518 on Page 117

Glossary of Relay Terms

School of Electrical Engineering, Oklahoma State University, Stillwater, Okla.—18 *page booklet*—Booklet entitled "Definitions of Relay Terms" is a glossary of words and terms in common use by relay users and manufacturers. Diagrams illustrate nomenclature for basic contact forms. Material, published by National Association of Relay Manufacturers, is based on an American Standards Association publication.

Circle 519 on Page 117

Solids Flow Meter

Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio—2 *page pamphlet*—Product specification sheet M22-6 describes the operation of a solids flow meter developed for the volumetric measurement of granular materials such as coal, ore, and crushed rock in vertical ducts, spouts, or pipes. Features discussed include minimum torque requirements for operation of counters, and air purging of bearing surfaces.

Circle 520 on Page 117

Instrument Tubes

CBS Electronics, Technical Information Services, 100 Endicott St., Danvers, Mass.—8 *page bulletin*—Bulletin PA-391 describes characteristics and uses for a line of instrument tubes, manufactured specifically for instrument manufacturers. The line is designed to meet the particular requirements of electronic equipment manufacturers. Tubes feature a 48-hour stabilization of electrical characteristics, 100-hour early life assurance test, special 1000-hour life test, and 5000-hour informational life test. They are warranted for 10,000-hour life.

Circle 521 on Page 117

Numerical Control Handbook

Friden Inc., Promotion Planning Dept., 97 Humboldt St., Rochester 2, N. Y.—32 *page handbook*—Booklet presents data on the history of metal removing equipment from the year 1750 to the present. The significance and promise of numerical control are explained. Sections of the booklet describe the programming and use of punched tape in machine tool applications. Examples cite savings that have been realized with numerical control versus conventional methods. Achievements in standardizing tapes and programs are noted. Booklet concludes with a description of a Flexowriter automatic writing machine that punches and verifies 8-channel tapes for numerical control applications.

Circle 522 on Page 117

Box Closure Methods

Acme Steel Products Div., Acme Steel Co., 135th St. & Perry Ave., Chicago 27, Ill.—20 *page booklet*—Commonly used methods of closing regular slotted containers and other corrugated boxes are described and compared in Booklet AD-230. Gluing both by machine and hand, taping with kraft-backed and reinforced materials, stapling, and stitching are all covered in this booklet. Also included are simplified and condensed quotations from Uniform Freight Classification Number 3, Rule 41—the basic guide to meeting common carrier shipping requirements.

Circle 523 on Page 117

Instruments and Controls

Hamilton Standard Div., United Aircraft Corp., Electronics Dept., Section D-60, Broad Brook, Conn.—Data sheets describe some of company's control systems, instrumentation, and energy conversion devices. Bulletin CSB-8.1-BA covers a pressure control system applicable in the chemical, petroleum, and glass industries. A liquid level warning system is described in Bulletin IB-4.1-AB, and a transient voltage suppressor designed to protect transistorized equipment is the subject of Bulletin ECB-8.1-AA. Features, specifications, and installation drawings are included.

Circle 524 on Page 117

Controlled Speeds Systems

U. S. Electrical Motors Inc., P. O. Box 2058 Terminal Ave., Los Angeles 54, Calif.—8 *page bulletin*—Form F-1952 illustrates and describes 12 controlled speed drive systems. These systems include: Liquid level control, pressure control, tension control, load control, position control, temperature control, multiple drive conveyor control, and lathe control for constant cutting speed. Brochure incorporates advances made in central control instru-

mentation, panel design, and signal transmission methods within these process-controlled automatic systems.

Circle 525 on Page 117

Press Modernization

Fawick Airflex Div., 9919 Clinton Rd., Cleveland 11, Ohio—8 page bulletin—Bulletin ML-200 compares economic and engineering advantages of power press conversions by three methods incorpating company's line of air operated clutches and brake. Methods involve: Complete engineering of new press drive systems; combining new power transmission units with reconditioned components; and adding new power transmission components to existing drive systems. A step-by-step analysis of a conversion process is included.

Circle 526 on Page 117

High-Speed Roll Feeds

Ferguson Machine Co., 7818 Maplewood Industrial Court, St. Louis 17, Mo.—8 page bulletin—Data are provided in Catalog 500 on a line of cam indexed Camtrol Roll Feeds for precision feeding of roll and strip stock to presses at rates exceeding 3000 ipm. Included are graphs for determining operating speeds and formulas for analyzing machine dynamics, selecting the proper acceleration characteristic, and determining correct roll pressures. Specifications of standard roll feeds for stock up to 12 inches in width, and feeding in varying increments, are given.

Circle 527 on Page 117

Worm Gear Jacks

Joyce-Cridland Co., 2027 E. 1st St., Dayton, 3, Ohio—28 page catalog—Subject of this booklet is a line of worm gear jacks that can be synchronized in any combination and may be driven by any convenient source of power. Ideally suited to many lifting, lowering, adjusting, and force-exerting applications, the jacks are available in capacities from 2 to 25 tons each. Typical drive arrangements are illustrated and data are provided on applications, repair parts, and accessories.

Circle 528 on Page 117

Contactors and Starters

General Electric Co., Schenectady 5, N. Y.—8 page bulletin—Line of NEMA size 3 and 4 magnetic contactors and starters is described in Bulletin GEA-7326. Pictures and diagrams show space savings made possible by use of new forms. Also pictured are the space saving dimensions of the entire 100-line from size 00 to size 4 starters and contactors. Sequence photographs show ease of contact inspection and coil change. Starter is pictured with call-outs to show construction features. Eight modification kits are listed and discussed.

Circle 529 on Page 117

Pump and Compressor Selector

Gast Manufacturing Corp., 2304 Fair Ave., Benton Harbor, Mich.—slide rule—Slide rule has been developed to aid in proper vacuum pump and compressor selection. When set at the required air flow in cfm at 0 psig, a choice of rotary air pump models is indicated. Setting the pointer on the opposite side of the selector then gives motor hp requirements and air flow characteristics over the range of 0 to 28 inches Hg vacuum or 0 to 30 psig pressure.

Circle 530 on Page 117

Load Controls

Machinery Electrification Inc., 56 Hudson St., Northboro, Mass.—32 page handbook—The application of load controls, or devices which continuously analyze the usage of electrical power by a machine or process, is described in this booklet entitled "Cutting Production Costs with an MEK Load Control." Techniques and advantages of using load controls are described. Diagrams illustrate applications in areas such as: Machine protection, automatic adjustment of machines and processes, and provision of "end of process" signals.

Circle 531 on Page 117

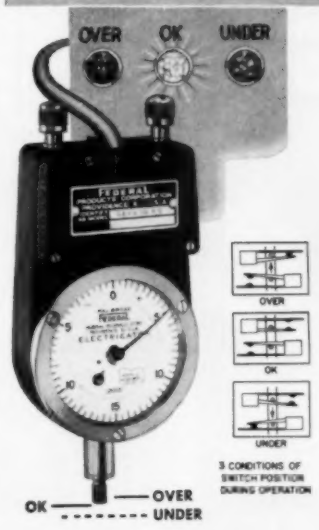
Handling Equipment

Young Machinery Co. Inc., Muncy, Pa.—4 page pamphlet—Line of materials handling and processing equipment is described in Bulletin 102. Details are provided on Transvair pneumatic conveying systems and components such as pumps, blowers, feeders, cyclones, horizontal mixers, sifters, knife cutters, saw tooth crushers, attrition mills, and pulverizers.

Circle 532 on Page 117

GAGE PAGE

A Quick Run-down of New Gaging Ideas



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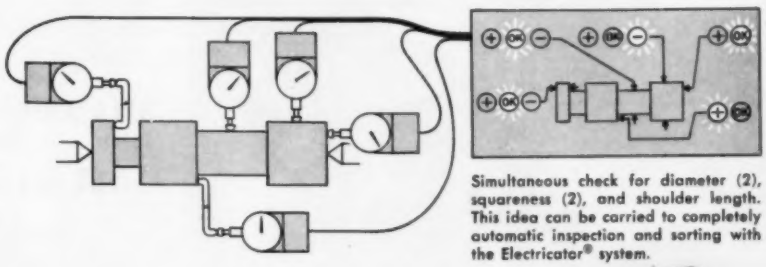
Want faster, more reliable gaging with less skilled help, less operator fatigue . . . and at a modest price?

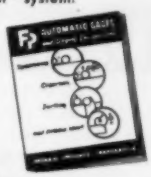
Electrify your operation with the FEDERAL Electricator® high accuracy unit . . . a Dial Indicator and precision switch combined. Replaces any AGD Group 2 (C size) Indicator . . . gives you light signals for "over", "under" and "good" . . . instantly. No borderline decisions to make, no dials to read, less chance of human error. Easily set to blocks. Good for tolerances down to ±.00025". Tolerance (switching) limits adjustable from on top.

What a job it does on multiple dimension fixtures (diagram)! No redesign necessary. Light panel gives you whole story at a glance. You can automate, too, with the Electricator® system.



Simultaneous check for diameter (2), squareness (2), and shoulder length. This idea can be carried to completely automatic inspection and sorting with the Electricator® system.

For complete specs, dimensions — the *whole* story — send for Catalog 60 AM.



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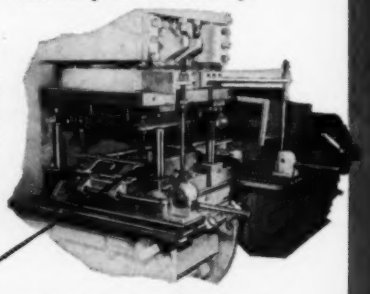
Circle 729 on Page 117

LIVERNOIS
TRANSFER UNIT

is the right move in your —

Automation with LIVERNOIS Standard Transfer Units are easily incorporated in new designs to fit large or small presses. Move any part, any distance vertically or horizontally.

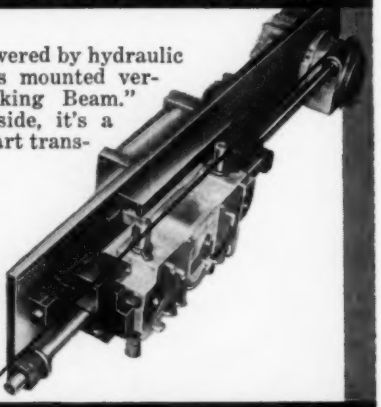
Die changeover is quickly made. Economical even for low volume production on new or existing equipment.



Press application of small 3-station line transfer unit shown.

AUTOMATION

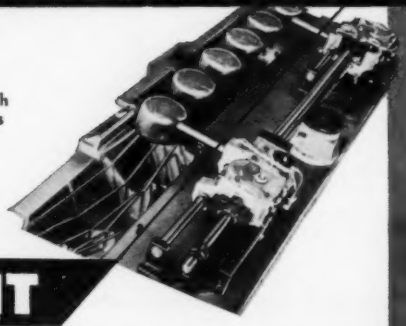
Standard unit powered by hydraulic or air cylinder is mounted vertically for "Walking Beam." Mounted on its side, it's a "Shuttle Type" part transfer unit.



There is a LIVERNOIS *Transfer Unit available for most applications*

TRANSFER

Patented—with other Patents Pending



UNIT

Large cup trimming shows the "BUILDING BLOCK" arrangement using hydraulic power.

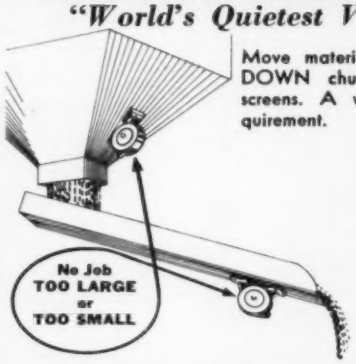
Write for 8 page illustrated brochure.
Or, *call* Detroit Code 313 CR 8-0200.

LIVERNOIS ENGINEERING CO.
"The Moving Engineers of Automation"
25200 Trowbridge • Dearborn, Michigan

Circle 730 on Page 117

VIBROLATOR® VIBRATION INDUCERS

"World's Quietest Vibrators"

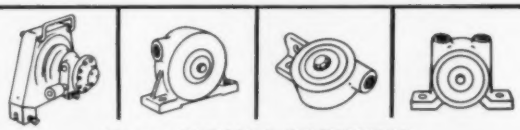


Move materials OUT of hoppers, DOWN chutes and THROUGH screens. A vibrator for every requirement.

FEATURES:

- LONG LIFE
- RUGGED
- POWERFUL
- UNIQUE DESIGN
- PATENTED THROUGHOUT
- UNCONDITIONAL GUARANTEE

FREE 30-DAY TRIAL ON ALL SIZES.
Stocking distributors coast-to-coast listed under VIBRATORS in the Yellow Pages.



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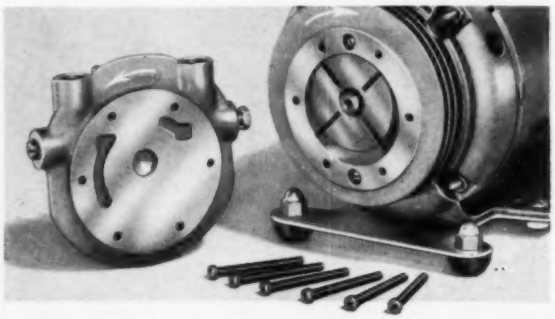
Circle 731 on Page 117



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Select sizes from .35 up to 24 c.f.m.

GAST OIL-LESS* AIR PUMPS

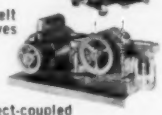
Miniature Models

These Oil-less Air Compressors and Vacuum Pumps offer you:

1. Absolutely oil-free air delivery.
2. No lubrication required — no need to arrange access for oiling.
3. No oil to buy, no time spent in oiling.

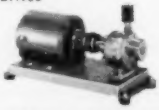
Integral-motor Types

V-belt Drives



Carbon vanes in rotor lubricate themselves. Ball bearings are grease-sealed for life and located outside pump chamber. Pressures to 10 p.s.i.g., vacuum to 20" Hg.

Direct-coupled Drives



*Lubricated models also available.

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Circle 732 on Page 117

AUTOMATION abstracts

ON-LINE PROCESS ANALYSIS

By W. F. LORANGER
X-Ray Department
General Electric Co.
Milwaukee, Wis.

X-RAY EMISSION can be described as the analysis of materials (both qualitatively and quantitatively) by elements present, unlike x-ray diffraction, which generally refers to the analysis of materials by compounds present. The transition from x-ray laboratory control to x-ray on-line control is of growing importance to industry today, particularly in view of the rapid progress in computer technology. Data loggers and computers are capable of storing and assimilating much information which can be used, with short time constants, as a basis to control process lines. Of utmost importance is the concurrent development of many types of primary sensors. One such primary sensor is the General Electric x-ray emission gage (XEG).

The XEG is designed for the simultaneous quantitative measurements of up to six different elements in a given material. The range of elements is generally from atomic numbers 13 to 92 (aluminum to uranium). In some special cases, it may be possible to measure magnesium (atomic number 12). The gage is composed of the sensing head, sample presenter, and electronics circuitry and cabinet. Together with an appropriate read-out device, such as a strip chart recorder, or integrating ratemeter print-out, these components, then, form the continuous analyzer or "sensor system." The head contains the x-ray tube, crystals, slits, counter tubes, and amplifiers, and can be used with or without a helium atmosphere. The electronics cabinet contains the high voltage transformer, ratemeters, power supply, and pulse height discriminators. When the automatic standardizer is included, a permanent standard sample is also included in the head. The sample presenter may or may not include a "window" between the head and the sample depending upon the application. Sample is fed continuously to the hopper on the presenter and after passing through the x-ray beam is discharged at the base of the presenter.

Theory of Operation

If a specimen (stationary or moving) is irradiated with a strong (50 kvp and 50 ma or higher) beam of x-rays, it will emit secondary (or fluorescent) x-rays whose energies are characteristic of every element in the sample, generally independent of the state of combination of that element. This beam of secondary

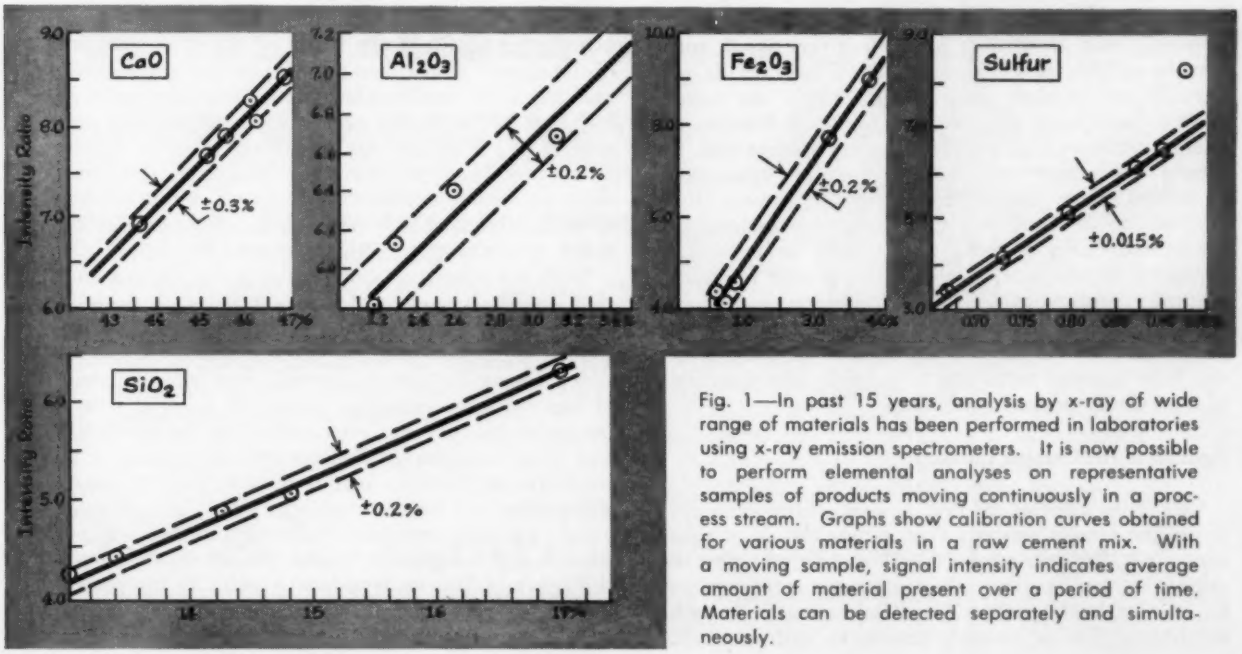

Fig. 1—In past 15 years, analysis by x-ray of wide range of materials has been performed in laboratories using x-ray emission spectrometers. It is now possible to perform elemental analyses on representative samples of products moving continuously in a process stream. Graphs show calibration curves obtained for various materials in a raw cement mix. With a moving sample, signal intensity indicates average amount of material present over a period of time. Materials can be detected separately and simultaneously.

x-rays (comprised of many energies or wavelengths) can then be dispersed (separated) into component wavelengths by large analyzing single crystals. Each wavelength can therefore be detected separately and simultaneously by utilizing a number of slits, crystals, and counter tubes (one for each element) which, when arranged in the proper geometric (Bragg) relationship with one another and the sample, form analyzing "channels."

The signal from the counter tube is then amplified and converted by electronic circuitries to produce a voltage level directly related to the radiation intensity as emitted by the element in the sample. This intensity is generally proportional to the amount of the element present in the material. Absorption effects may be present, however, that vary with the matrix of the materials to be analyzed, and the particular element to be analyzed in a given matrix. As the output signal increases or decreases, the amount of the element has correspondingly increased or decreased. The variation in output is calibrated from material, similar to that which is to be continuously analyzed, with known amounts of the element present. Thereafter, the signal is read in terms of the desired quantity. In a case in which the sample is stationary, the signal represents the amount present in the areas as seen by the counter tube. With a moving sample, the signal indicates the average amount present over a period of time. By increasing or decreasing the response time of the circuitry, it is possible to measure variations which are either long term trends or short term variations in composition.

Sample preparation and presentation specifications vary greatly with the application, as well as with the degree of precision required by the user. The depth of penetration into the sample by the x-ray will depend upon the target material of the x-ray tube, the excitation voltage and tube current, the distance of the sample from the x-ray tube, whether air is excluded in the x-ray tube to sample path, the use of a "window" between sample and x-ray tube, and the sample itself. Generally, this depth of penetration is very small, and may be as little as 0.001 inch to 0.005 inch. This essentially means that, although the x-rays are penetrating (and must then emerge from the sample as characteristic x-rays), the precision of the method is greatly dependent upon sample surface preparation. It follows, then, that with powdered specimens, the particle size distribution is an important consideration for reproducibility of data. The sample surface when presented to the x-rays (whether manually or automatically continuous) should be uniform and truly representative of the whole sample. The manner of presentation of the sample will depend upon the form the bulk material takes and is generally characteristic of a particular processing industry.

Applied to the Cement Industry

One of the applications that appears greatly attractive to on-line process analysis (and ultimately, short time control) is the cement industry. There are a number of cement companies using laboratory x-ray spectrometers for routine batch analysis for different materials such as clinker, finished cement, limestones, and raw mix. It becomes especially advantageous to apply continuous x-ray analysis to the raw mix feed to the kilns. The initial installations of the x-ray emission gage in the cement industry are for this purpose in a dry process area, and a representative portion of the raw mix stream is fed to the dry powder presenter for analysis. Elements of interest vary with raw materials used, but are mostly confined to calcium, aluminum, silicon, iron, sulfur analysis. Although there is a great interest in magnesium (MgO) analysis in a number of instances, this has not yet been attempted on-line.

Fig. 1 shows calibration curves for CaO, Fe_2O_3, Al_2O_3, SiO_2, and S in dry raw mix. The calcium and iron channels were calibrated with a 30 second time constant, and the aluminum, silicon, and sulfur channels were calibrated with a 60 second time constant. The relationship between the points on each calibration curve may be established by the least mean squares method. Tolerances are established as indicated on each curve for plus or minus per cent deviation from the line, such as plus or minus 0.3 per cent for the calcium oxide. The intensity data is plotted as a ratio of the signal to an electrical reference, so that output is always in a range of 0-10 volts. A voltage divider on the strip-chart recorder, which was used as a read-out device for these analyses, reduces the signal to a 0 to 10 millivolt range, for which the recorder is designed to measure. The data is quite linear over the ranges analyzed although one occasionally encounters a spurious reading, such as the sulfur curve at 0.92 per cent. This was rechecked by wet chemistry and found to be in error, and when replotted on the curve for x-ray analysis, was found to fall within the limits of plus or minus 0.015 per cent. It might be interesting to point out that direct on-line x-ray analysis of a raw mix slurry does not appear possible for elements other than calcium and iron. Even the direct analysis of these elements in a slurry is not without some difficulty. X-ray analysis (on-line) of the aluminum and silicon in a raw mix slurry is not possible because of the high attenuation of the x-ray beam by the water content of the slurry. What does appear practical and feasible, and has been accomplished on a laboratory basis so far, is the flash drying of a slurry raw mix and presenting the resultant dry powdered material to the x-ray gage head continuously. Therefore, it appears that successful application of direct x-ray on-line analysis of cement raw mix can be expected in either a dry or wet process plant.

With the advent of simultaneous x-ray instrumentation, in which read-out for a number of elements in any given material can be accomplished in an extremely short time (order of minutes or less), it appears that x-ray on-line process control looms into the future of many process industries. Once the material from a particular industry has been studied in the laboratory and x-ray analysis is demonstrated as feasible to a particular application, then it remains only to couple the process line to the x-ray analyzer. The ultimate value of such a procedure varies with process application, and the degree of success greatly depends upon the user's ability to determine a point in his process stream for continuous sensing, and deliver to the XEG a representative portion of his main stream. The

value of such an analytical proccedure, particularly from a quality control or trend analysis standpoint, can hardly be overemphasized.

From a paper entitled "On Line Process Analysis by X-Ray Emission Technique," presented at the 12th Annual Symposium on Spectroscopy, Chicago, May 1961.

NOT MORE, BUT BETTER

By OWEN SMITH
First Vice President
Statistical Tabulating Corp.
Chicago, Ill.

THE EXCEPTION PRINCIPLE in managing is an old idea with its roots in human nature itself. It simply states that a person in charge (a manager) pay routine attention only to important matters requiring his action. Such matters are exceptions relative to all other possible matters which, in turn, are delegated to subordinates or disregarded.

In practice, this law is honored more often in the breech; and when followed is usually accidental. We have a common example of accidental management by exception when the "boss is busy" and "can't be bothered." This situation of accidental exception has its roots in management's disinclination to follow rational exception procedures. The "busyness" of the manager is due to his inclination to want "all the information" that is available. He feels that by having this mass of detail pass over his desk he is keeping in close touch with the entire business.

This tendency gets progressively more absurd and more dangerous. For we have now, in electronic computers, the literal ability, not to swamp, but to bury a manager. In one situation, that must remain unnamed for obvious reasons, daily sales reports from a 1957 model computer to one sales division manager's office, ostensibly for his personal perusal, measured four feet high. Professor John M. Allderige of Cornell University puts it none too strongly, when he wrote. . . "We are easily in danger of wallowing in ever-greater complexity in this management business . . . . there is the general idea that refinement and insight are the same in management problems . . . that if more information is obtained faster, all problems can be solved . . . overwhelmingly detailed data processing systems can be very real blocks to progress both in the money they can cost and the knowledge they can retard by all that clutter."

The only answer is the planned, not accidental, use of the exception principle. The principle is being intelligently used today. But there is a possibility of even greater use. This principle is important even if it is not utilized on a computer. For example, the Allerton Chemical Company in Rochester, N. Y., operates a visual inventory system without the customary stock ledger cards. Only the exceptions in the form of raw materials at or below the order point are reported or recorded. Needless to say, exceptional control can reap

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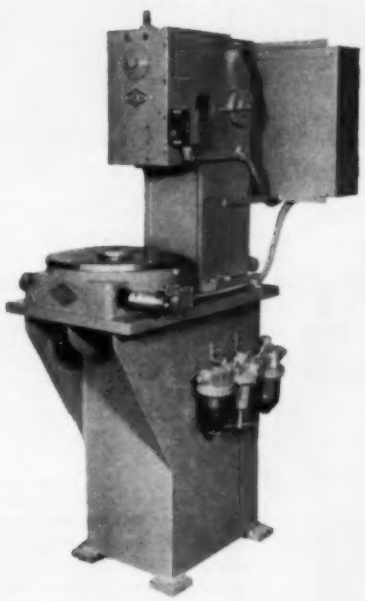

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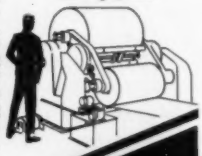

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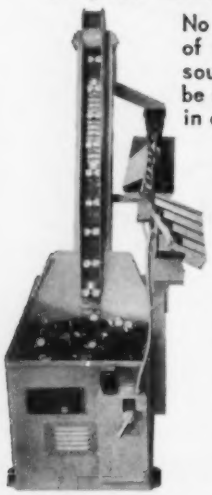

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enormous benefits. Let me cite an excellent example. The Westinghouse meter plant in Newark, N. J., is reported to be saving a cool million dollars a year by computer inventory control. Using sales figures, and taking into account the costs of labor turnover, machine set-up, and so forth, the computer decides when to stock an item formerly produced to order, when to adjust the inventory of an item losing popularity, etc.

Note the key word is decision. The computer can make decisions and must be allowed to do so. But it can't think. It can only decide on the basis of decision rules established by management. Exceptions to standard performance are reported. Then management can decide according to the amount of variance whether the manager should investigate the situation further. If exception control is working there will be less data and fewer and shorter reports being passed around. You'll be reading about the exceptions on which you must take action rather than reading yourself blind just to find out that everything is dandy . . . you'll be thinking about getting the routine decisions made for you, rather than getting reports upon which you must make the decisions.

Current Confusion

One of the tragedies of computer use today is the automation of current confusion. It isn't sufficient to just state old rules. New rules must be designed to take advantage of the new technology available. It should be noted that the decision rules can be rather complex. We have both the mathematical insight to concoct detailed rules as well as the computer capacity to handle the complex mathematics. Indeed, this leads to another danger substituted for the afore-mentioned danger of excessive reporting—the danger of over-complicated exception criteria. This usually stalls for some time the installation of effective controls. The current brand of operations research people must be watched and prodded so they don't get carried away with the delights of analysis. We must be aware of confusing figures with facts.

The difficulties are enormous—we have a staggering capacity for information storage and emission. It is natural, moreover, for us to be pleased with this truly amazing accomplishment and push it even further. But it mustn't be done without awareness of the social impact on people. Nuclear development has forced upon society new political problems and social solutions. Computer advances are forcing on management society, new channels, forms of conduct, and a re-programming of our thinking.

Of course, we can't afford to generate all the facts, information, and data that we are capable of producing. We have seen that it is necessary to channel all the noise we are capable of and make it intelligible. This channeling presents a very real human problem in decision rule design. Unconsciously the manager very often resents mathematical models for decision making; the programming of the computer which enables it to make judgments. He can view it as an afront to his personal contribution of making decisions in complex and uncertain situations. We can't jam computerized mathematical decision-making down management's throat and yet we can't afford not to have it.

Somehow, someway, this "new thought" must be conveyed: We must convince the manager that these apparent encroachments on managerial prerogative are really opportunities for far greater leadership. Managers are hardly running out of problems as science moves in on schedules, budgets, inventory levels, production planning, and the like. True, the unimaginative may run out of vision. But all this science in business is really releasing executive talent for its basic job of broad leadership and creativity. The challenge, then, is to harness our massive information potential to useful purposes.

From a paper entitled "Management and Control by Exception," presented before the 1961 *Annual Seminar of the National Association of Accountants, St. Louis, May* 1961.

PROGRAMMING BATCH PROCESSES

By FORREST E. HEAD
Engineering Specialist
Engineering Dept.
Organic Chemicals Div.
Monsanto Chemical Co.
St. Louis, Mo.

PROGRAMMERS for batch processes can have an important effect upon chemical processing. In the search for greater profits, continuous processes are being considered as a replacement for batch operations. This is not always a sure road to more profits because today's equipment costs are high. In addition some products do not lend themselves to continuous processing. This is especially true of chemicals that are the products of slow chemical reactions. As a rule such products have been made in batch reactors. A way to make many batch processes more profitable is to consider programming.

A programmer for a batch process is a mechanism that automatically advances the batch through its processing stages. In each stage the mechanism sets up preselected operating conditions and then waits until the required end point is reached. At the end point a signal from the process tells the mechanism to advance the batch into the next process stage. This sequence automatically continues until the end point of the last process stage is reached.

This programmer differs from earlier control systems for batch processing in one important respect. In the earlier systems the batch was advanced through its stages according to a time schedule. A preselected time period was scheduled for each process stage. Because of the time schedule, no attempt was made to see that each stage reached the same end point in every batch. With the programmer, the batch is advanced only after the required end point of each process stage is achieved. This difference means that with the programmer the same end points are reached in every batch.

With successes in other industries to guide us, in 1956 the Queeny Plant Technical Service Department started to design Monsanto's first programmer. The resulting installation increased production more than

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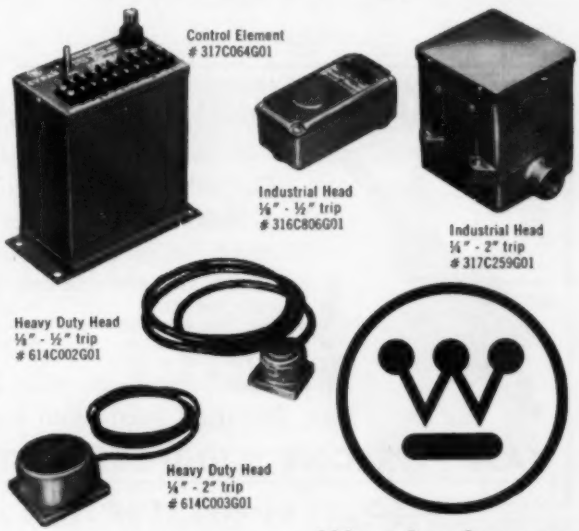

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20 per cent, paid for itself within six months, and was welcomed by the operators. The cost of maintaining it and its auxiliary equipment has been less than $200 per year. In the Everett Plant on another process, a programmer was installed in 1959. The results were similar; production was increased by more than 25 per cent, the payout period was less than six months, and the working force welcomed the programmer.

In one example, a 20 per cent gain in output was obtained in a batch reactor process for making an ester. The process is considered as starting with an empty reactor and all of the reactants available. As the dibasic organic acid is mixed into the alcohol the half ester starts forming. Half ester formation is completed by refluxing the entire batch for a preselected time period.

The addition of a third reactant starts forming an intermediate and two byproducts. The intermediate's formation is forced to completion by distilling off all of the byproducts. The reactor's temperature rises to a preset level when this reaction is complete. The addition of a fourth reactant starts forming the ester. Its formation is completed by refluxing the batch for a preselected time period. The excess raw material is driven off until the reactor pressure and temperature reach the desired end points. Then the ester is pumped out of the reactor to make way for the next batch.

There are two reactors with a common vacuum system. One workman operated both lines before the changes were made. From this equipment the production supervisor wants the maximum number of pounds of ester each month. In trying to achieve this he runs headlong into several problems.

The problems limit the throughput and result in non-uniform processing of each batch. One solution is to increase the worker's effectiveness by using mechanisms that enable him to better oversee all the processing operations. With that thought in mind, the following were selected to keep the workman near the reactors and their control panel:

An automatic cutoff system for the measuring tank was selected to replace a system requiring the worker's presence at the measuring tank. The worker at the control panel decides when to fill the tank. He starts the pump from a pushbutton on the panel, but he does not stop the pump. It is automatically stopped by the tank level reaching a preselected height.

Motorized valves were selected to replace all the frequently used hand operated valves. These motorized valves were to be positioned from the control panel at the reactor.

An automatic timer was selected to tell the worker that the refluxing period was over.

A time schedule pressure controller for the vacuum system was selected to replace the conventional pressure controller. This made possible a scheduled reduction in the reactor pressure. The preselected schedule insured a fast distillation without any carry over.

A more precise steam pressure control system was selected for the heating jacket on the glass lined reactor. This kept the steam pressure at the maximum safe value during all the load changes.

All the above mechanisms help to keep the worker available for advancing the process into the next stage, but these mechanisms will not insure that the ad-

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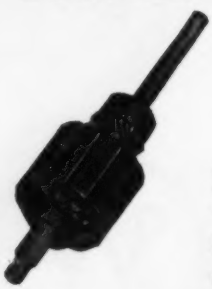

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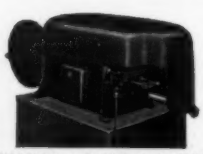

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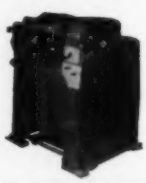

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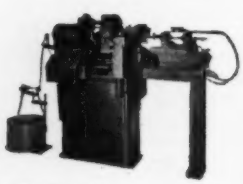

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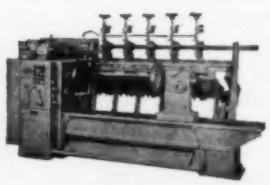

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vancement is made at the first possible opportunity. For example, the timer can tell the worker to stop the refluxing period but he may delay stopping it until he finishes a more important duty. To minimize the delays caused by these conflicts, the operation of the above mechanisms was put under the control of a programmer.

In designing the programmer for this reactor the more complex and/or important operations were reserved for the worker. The worker was made responsible for having the reactants available, for charging them into the reactor, for starting the programmer, and for pumping out the product. The remaining physical manipulations were done at the command of a programmer for each reactor. These manipulations were to open and close the eleven valves associated with each reactor.

The batch processing equipment produced 20 per cent more ester after being programmed. An examination shows that the gains came about because the programmer: 1. Starts each step at the earliest opportunity. 2. Simultaneously does several physical manipulations. 3. Aids the supervisor in finding and in using the best processing conditions for each process stage.

Developing A Programmer

A batch process to be a good candidate for a batch programmer should have three characteristics: 1. The production rate is uniquely limited by the operating conditions. 2. The mechanization of the physical manipulations is possible. 3. The control of these mechanisms can be centralized; e.g. at an instrument panel.

A process that is limited by the operating conditions is one in which the productivity is limited because the workman: 1. Cannot advance the batch into the next process stage at the first opportunity. 2. Cannot simultaneously do several tasks that are in separate locations. 3. Cannot easily select the optimum rate of change for each process variable.

If a process is to be mechanized, mechanisms must be found to manipulate process devices. The mechanisms will have a common characteristic; in most cases the mechanism will complete a task the worker starts. He may start it by pressing a button, by throwing an air switch, or by starting a controller. It is not necessary that all the operations or problems be mechanized.

The third characteristic was that the control of the mechanisms can be centralized in one area. In this area should be all the information about the process that the worker needs. This includes the indicating, recording, and/or controlling portions of the mechanisms selected to manipulate process devices. From the central point the worker will be able to operate most of the process equipment.

The extent of the workman's manual efforts is fixed by an arbitrary decision. Normally the more complex and/or important duties are reserved for the worker. In the ester example, the worker personally monitors the charging and pumping out of the reactors. These tasks could have been made completely automatic but by choice were not.

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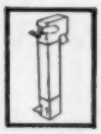
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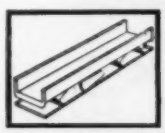
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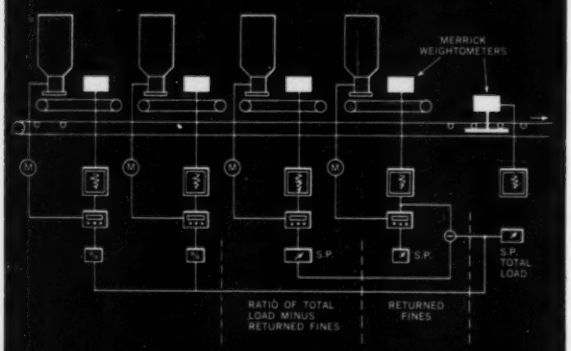
Here's how Weightometers can automate a typical blending system . . .



Loading is made at the set-point station, which imposes an output voltage signal to all ingredient control stations. All materials are controlled to a percent of the total load required. Recoverable material set-point is determined by returned product available. Feed is controlled by difference of returned material and total load of master set-point.

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more detailed analysis of the process and the programmer should be made. The process is divided into stages. The programmer's steps and signals are listed. Finally, the position of each function during each step is shown. With this work completed the following question often arises.

"Won't the mechanization without programming offer a greater return on the investment?" To date the answer is "No." The additional cost of the programmining mechanism has been less than 20 per cent of the cost of the mechanisms being programmed. With the programmer the total gain is greater than the sum of the individual gains due to each mechanism. This is principally because the programmer aids in finding and in continually using the best operating conditions in each process stage. The over-all gain is increased more than the 10 to 20 per cent increase in capital investment caused by the programming mechanism.

From a paper entitled "A Programmer for Batch Processing," presented at Winter Instrument-Automation Conference, Instrument Society of America, St. Louis, January, 1961.

PLANNING ENSURES SUCCESSFUL NC

By PETER RUSNOV
Chief Industrial Engineer
Warner & Swasey Co.
Cleveland, Ohio

AS MANUFACTURERS of machine tools and control systems and as users of numerical control in our own Warner & Swasey plant we have found that equal emphasis must be given to design, planning, and manufacturing when integrating numerically controlled equipment into the organization.

Efficient use of numerically controlled equipment forces complete and critical pre-planning of every aspect of manufacturing operations. Many of the high-cost reductions attributed to the introduction of numerical control into a plant could have been realized without numerical control through proper organization and improved communications. This phase of pre-planning for numerical controls is a responsibility that cannot be passed on to the technicians who install your new machines and put them into working order.

Fortunately for us, the introduction of numerical control caused no appreciable change in our planning organization or its function. We have not had to create an entirely new department to plan for numerical control. Our Manufacturing Planning pre-dates numerical control and was organized as a part of our Wage Incentive Plan. Techniques that we have been using in our planning for conventional equipment can be used without change in our pre-planning for the use of numerical control.

Because numerically controlled machine tools must deal with parts already released to the shop and with those yet on the drawing boards, some form of design review committee is needed to assure good future designs. At Warner & Swasey, a group of specialists in

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product design engineering, manufacturing planning, and manufacturing meet weekly and review all new designs in their conceptual stages prior to release for production. By contributing valuable knowledge and experience, this experienced panel helps create a more efficient working relationship among manufacturing, manufacturing planning, and the product design engineer. Improved communications between members of this committee minimize subsequent call-backs and requests for changes after release.

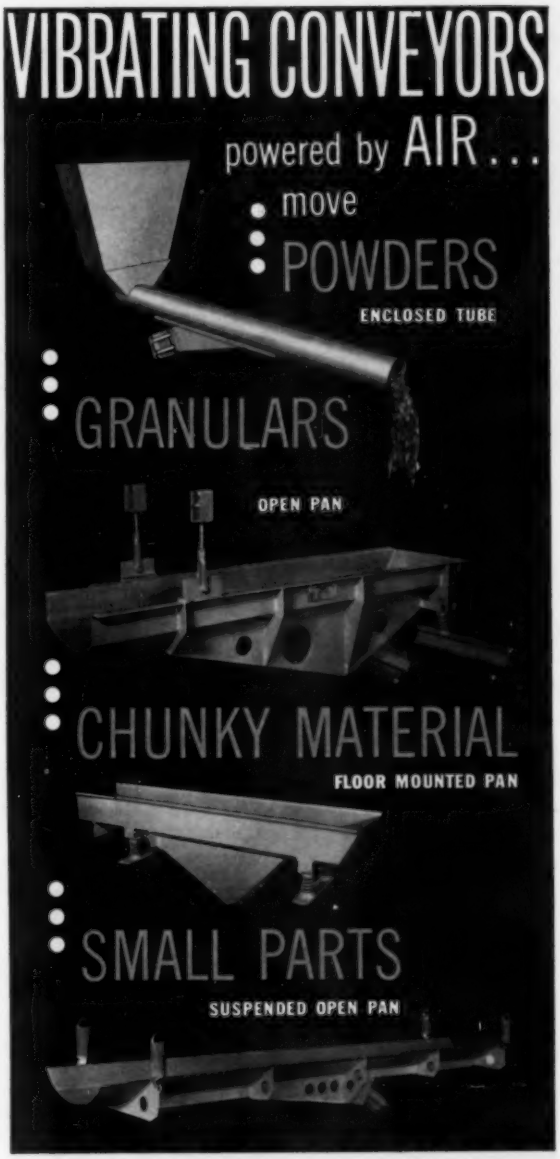
As a member of this manufacturing planning committee, the product design engineer soon realizes these facts:

1. He must still design simple, economically producible shapes. Since parts must still be held by conventional means, numerically controlled machining can still present problems in terms of irregular shapes, non-uniform sections, and abrupt changes in section.
2. He will be given greater freedom of design in that he is not bound by present tooling and processes. Poor design need not now be tolerated because of reluctance to scrap existing tools.
3. Numerical control will force him to convey the engineering requirement with greater clarity for both planning and manufacturing.
4. He must standardize hole and tap sizes to permit planners to process the parts in one operation using only those tools which can be handled automatically.
5. His surface roughness designations, his specifications of geometric and dimensional tolerances determine feeds, speeds, sequence of cuts, and the ultimate cost of the part.
6. Numerical control requires that he dimension in a way that spells out the engineering requirement, so that the planner can convert easily as he writes his manufacturing plan to whatever method of dimensioning suits the particular numerically controlled process best. He will no longer be forced to continually revise his engineering drawings to suit the changing concepts of manufacturing and inspection dimensioning.

Our methods organization was changed little by the introduction of numerical control. Its work of writing the operation description, operation sequence, specifying equipment and special tooling has remained the same.

It is in the area of parts selection from presently tooled parts that the methods man must pay keen attention to economic justification. The numerically controlled machine is in competition with other numerically controlled machines and with conventional machines which have been heavily tooled to produce the present parts. The planner's choices will not be easy in that he must consider machine load, compatibility of holding devices and cutting tools, and the best utilization of the numerically controlled equipment. Predetermined standard data enables him to evaluate the best of many alternatives and to make the proper selection.

The rate-setting sections of the Standards Department logically became the parts programmers for numerical control operations, since they were already dealing with the sequence of work elements, speeds, feeds, selection of standard cutting tools, and with calculation of standard times for machining and setup. Except for having to learn the concepts and techniques of numerical control, the standards group did not change in size or function. No new people were added to program for the nine new units of numerically con-



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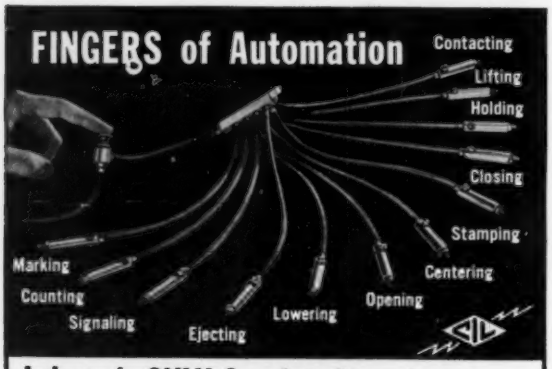

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trolled equipment initially installed in our Warner & Swasey plant.

Essentially the same detailed steps used in planning and rate setting for conventional equipment are used in parts programming for numerical control. The real difference is that words previously used to instruct the workmen in operating the conventional machine now become the taped instructions that control the machine. Because the tape is the by-product of typing the program, we found that very little more planning time was needed for numerical control programming.

Even though we have just made a beginning in numerical control, the Tool Design group is already designing fewer drill jigs and milling fixtures and more of the work-holding type of tools. To take full advantage of the flexibility of numerical control, more general purpose work holding fixtures will be needed. As we add more numerically controlled equipment, increased attention will be given to tool control, tool standardization, tool presetting, and tool presharpening.

Growing experience in the use of the new machines especially designed for numerical control has focused the attention of the tool designer on conventional equipment and its present inadequacies. Index tables using lockbolts are now too slow and not sufficiently accurate. Measuring bars once thought to be the ultimate in accuracy are now not sufficiently stable, are subject to wear, and not accurate enough when compared with numerically controlled equipment.

In the future, numerical control will change the tool design group but little organization-wise; but it will change their technology considerably. Tool designers can then devote more of their time to creating assembly tools and special machines which will reduce cost in non-machining areas.

If a company has relied heavily on operator and foremen skills for planning, it is in this area that most changes must be made when numerically controlled equipment is introduced. One of the great benefits of numerical control is that although it does not eliminate the great number of human judgment factors that arise in the manufacture of a product, it does place them in an area where they need be made fewer times.

Numerical control, in areas where we have applied it, has reduced the floor-to-floor manufacturing time 30 to 35 per cent as compared with conventional methods. Since our numerically controlled machines are competing with heavily tooled, efficiently organized, conventional machines, our savings seem conservative as compared with the more dramatic savings reported by some others. Most of our 30 to 35 per cent savings come from the reduction in setup and parts-handling time. Our reduction in tooling cost is generally about 50 per cent. Machining parts in the conventional manner ordinarily takes ten to twelve operations. With numerical control these same parts are made in two to four operations.

From a paper entitled "Planning and Programming for Numerically Controlled Equipment," presented at American Society of Tool and Manufacturing Engineers National Seminar on Automation and Numerical Control, Hartford, Conn., February 1961.

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By Harold E. Siosson, manager of shop operations, Knolls Atomic Power Laboratory (General Electric Co.); 352 pages, 6 by 9 inches, published by McGraw-Hill Book Co. Inc., New York; available from AUTOMATION; *$7.50 postpaid.*

This text provides an introduction to electronic measurement and control as used in the laboratory and industry. Included are chapters that establish the laws, terms, basic concepts, symbols, and nomenclature required for an understanding of the function of instruments. Following these basic subjects, the functions of components in an instrument system are discussed.

OPTIMUM DESIGN OF MECHANICAL ELEMENTS

By R. C. Johnson, staff engineer, International Business Machines Corp.; 535 pages, 5¾ by 9 inches, published by John Wiley & Sons Inc., New York; available from AUTOMATION; *$11.50 postpaid.*

Recognizing that an engineer typically can develop a multiplicity of satisfactory solutions to a design problem, the author has formalized an approach that will enable the "optimum" design to be obtained. He describes optimum design of a mechanical element as . . . "the selection of the material and the values for the independent geometrical parameters with the explicit objective of either minimizing an undesirable effect or of maximizing a functional requirement. . . "

THE PROCESS OF MANAGEMENT

By W. H. Newman, professor of democratic business enterprise and C. E. Summer Jr., associate professor of management, both of Graduate School of Business, Columbia University; 675 pages, 6 by 9 inches, published by Prentice-Hall Inc., Englewood Cliffs, N. J.; available from AUTOMATION; *$10.60 postpaid.*

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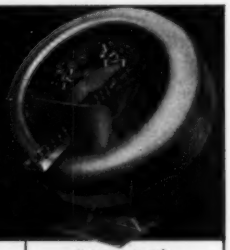

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CONVEYING COPPER CATHODES **Case 2435-P**

. . . I am interested in a preheat conveyor-elevator that could automatically feed 300 pound copper cathodes into an arc furnace at a rate controlled by furnace temperature. Also needed is an indexing mechanism to separate the cathodes and feed them one at a time onto the elevator. . . . **Industrial Engineer**

TESTING RESISTORS **Case 2501-P**

. . . I am interested in information on automatic test equipment which will determine the value of an unknown resistor in a bridge circuit and then energize an electronic switching circuit that will operate a solenoid or air cylinder. The test equipment should include a memory wheel or circuit so that the part could be accepted or rejected at the point of test or at a later position in an automated production line. . . . **Plant Engineer**

MAKING SHOULDER PADS **Case 2502-P**

. . . We are interested in knowing of any automated equipment that has been developed in connection with the manufacture of shoulder pads for men's clothing. . . . **Plant Engineer**

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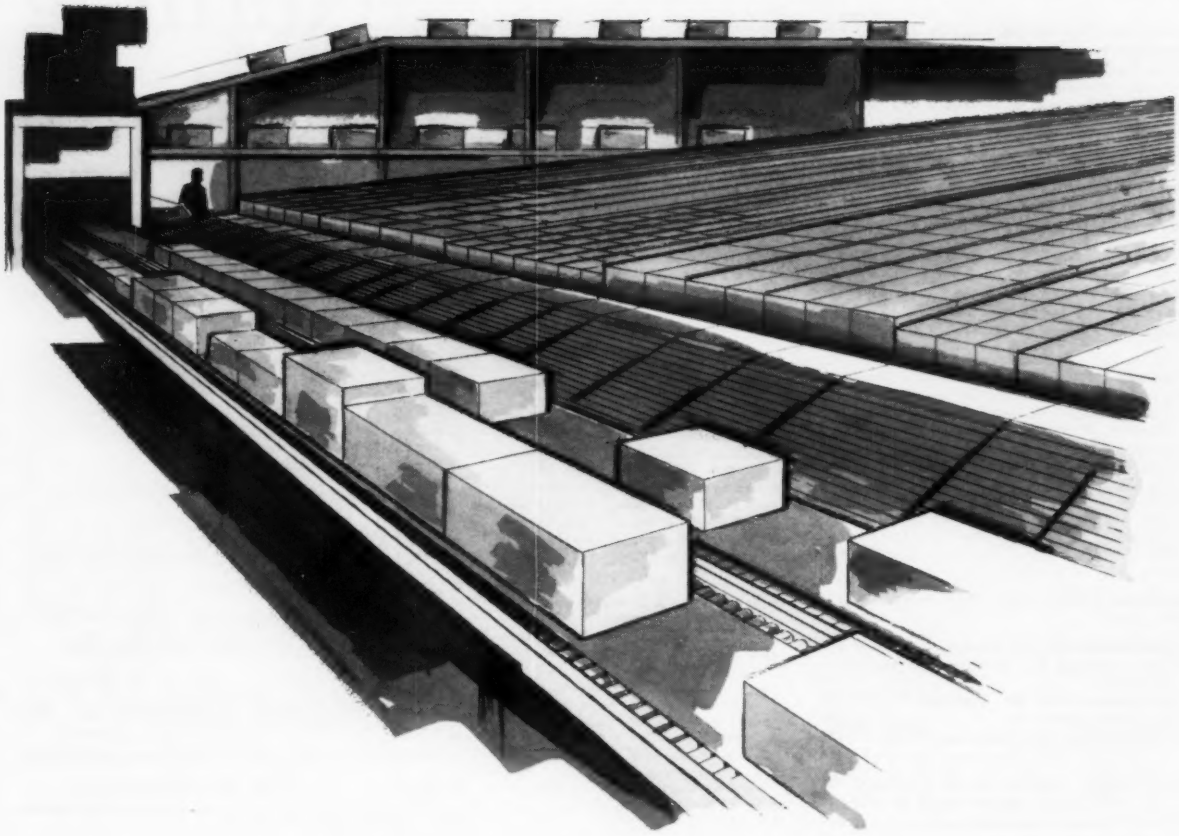

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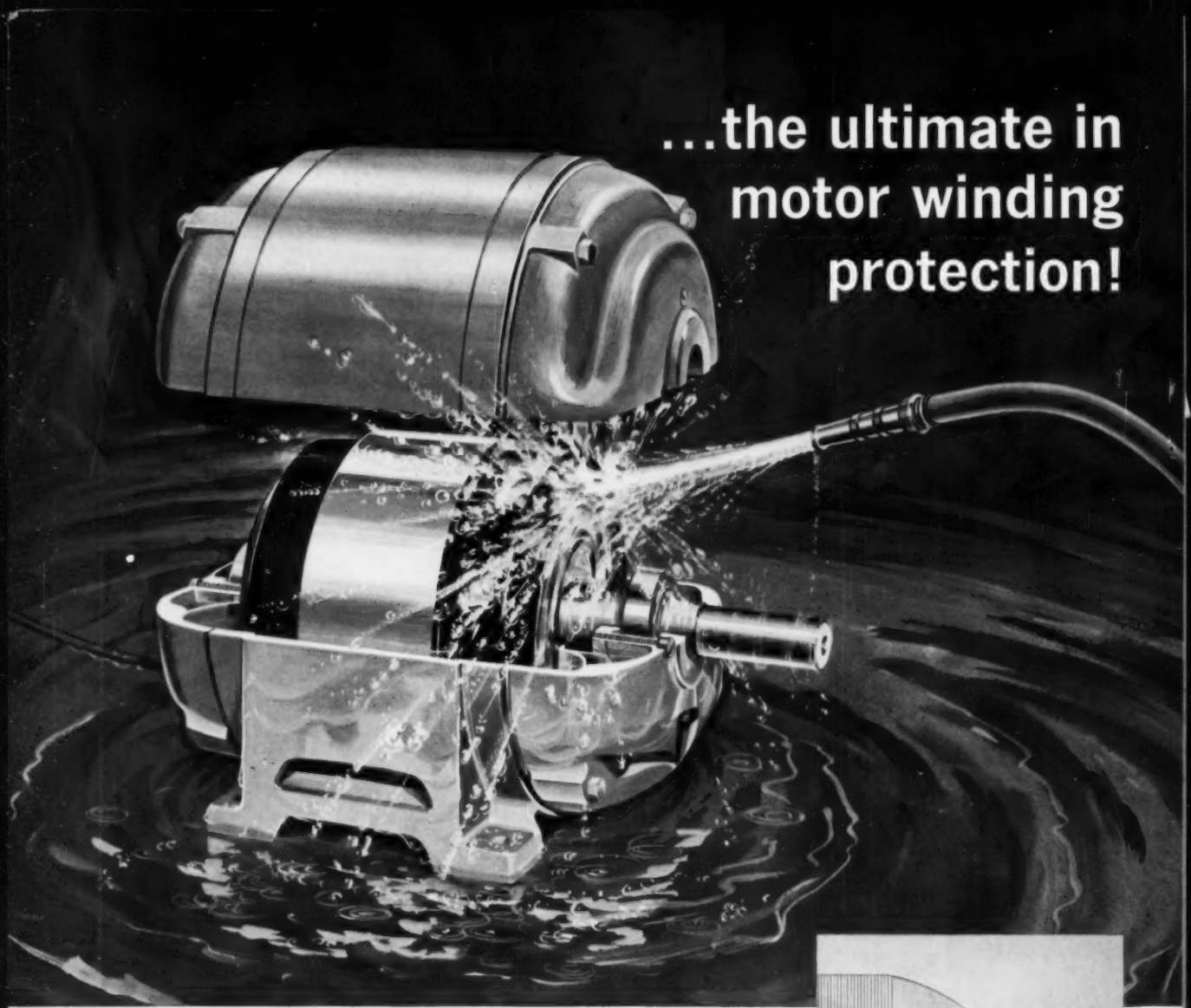

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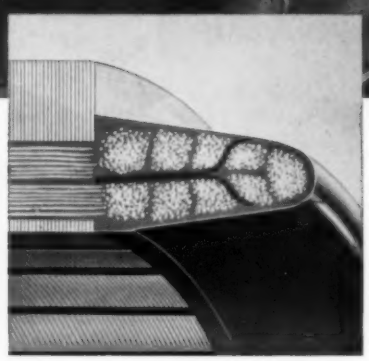

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